ECONOMICS OF PARTICLE BOARD INDUSTRY—See p. 6

Forest Products Journal

Vol. VII, No. 1 January, 1957

Molded Products—New Tool for Wood Industry and Outlet for Wood By-Products—See p. 1

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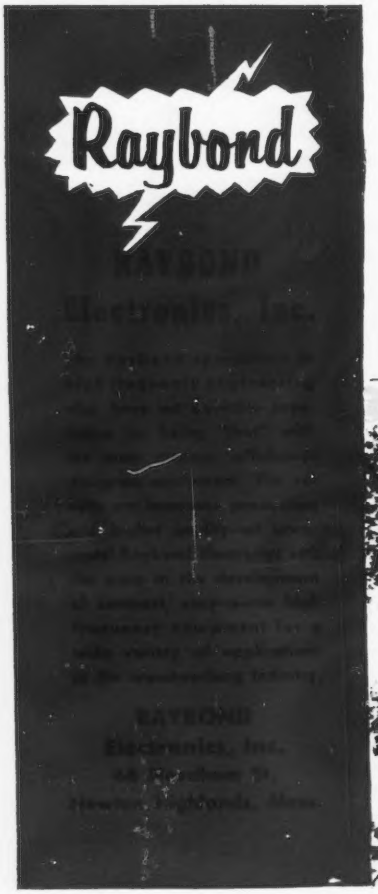

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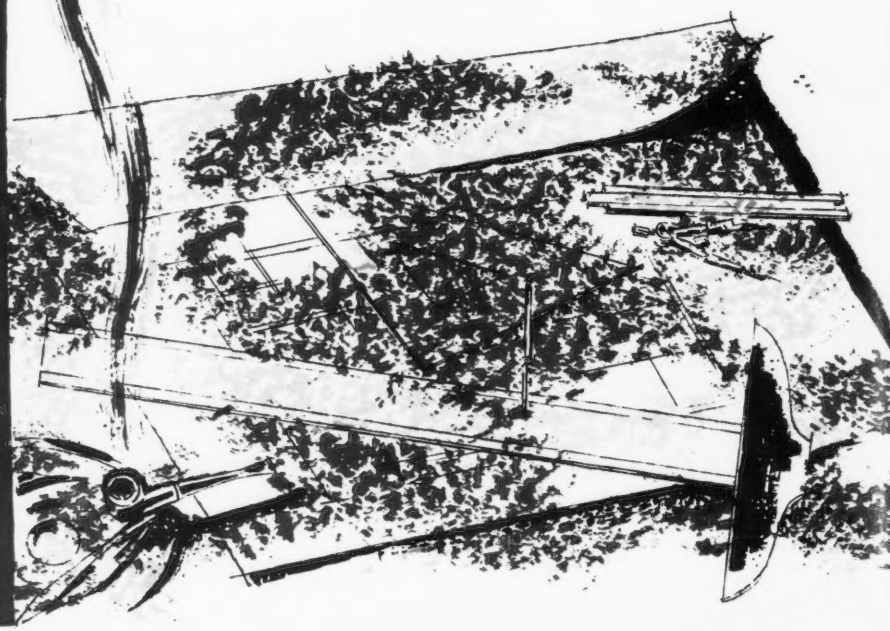

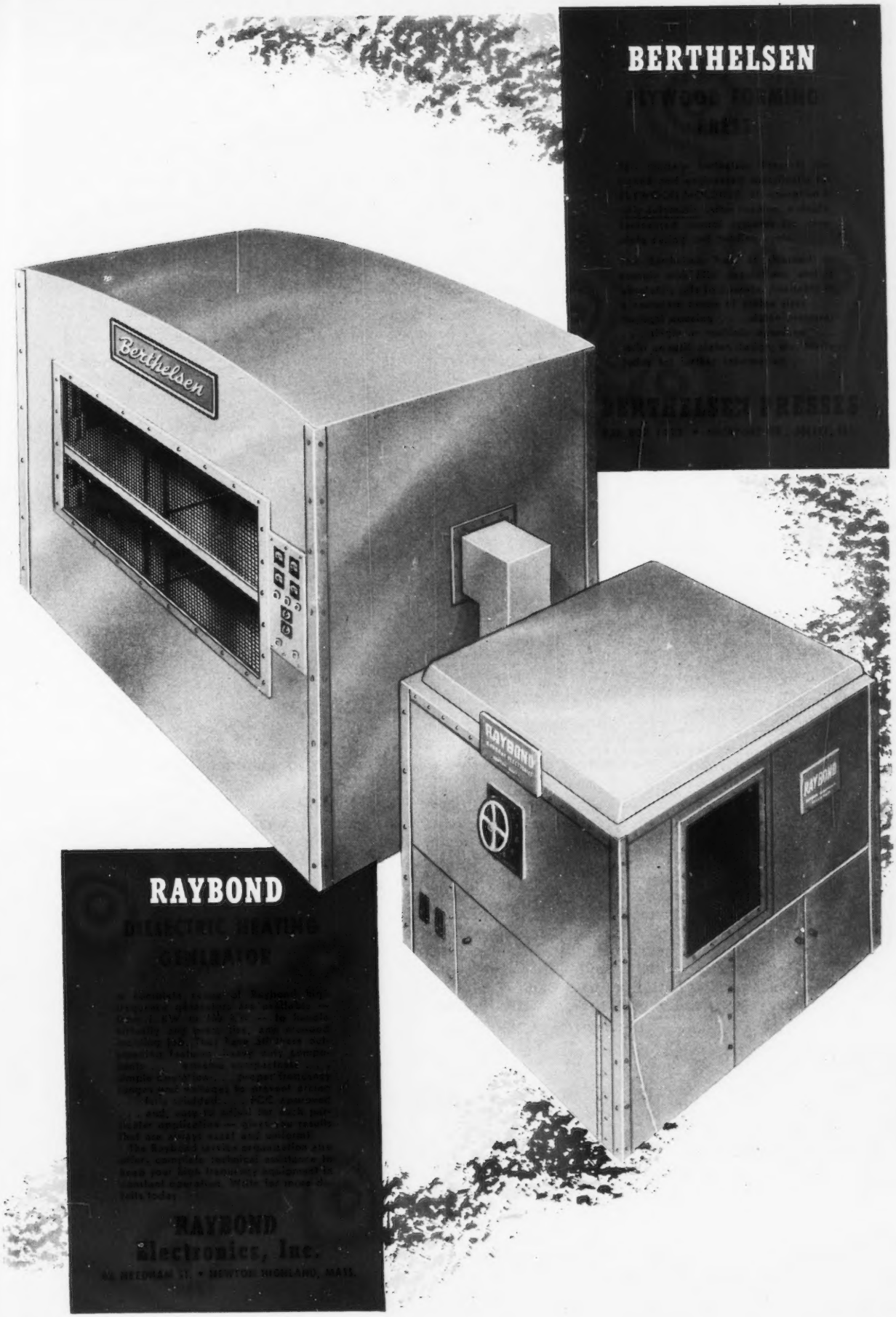
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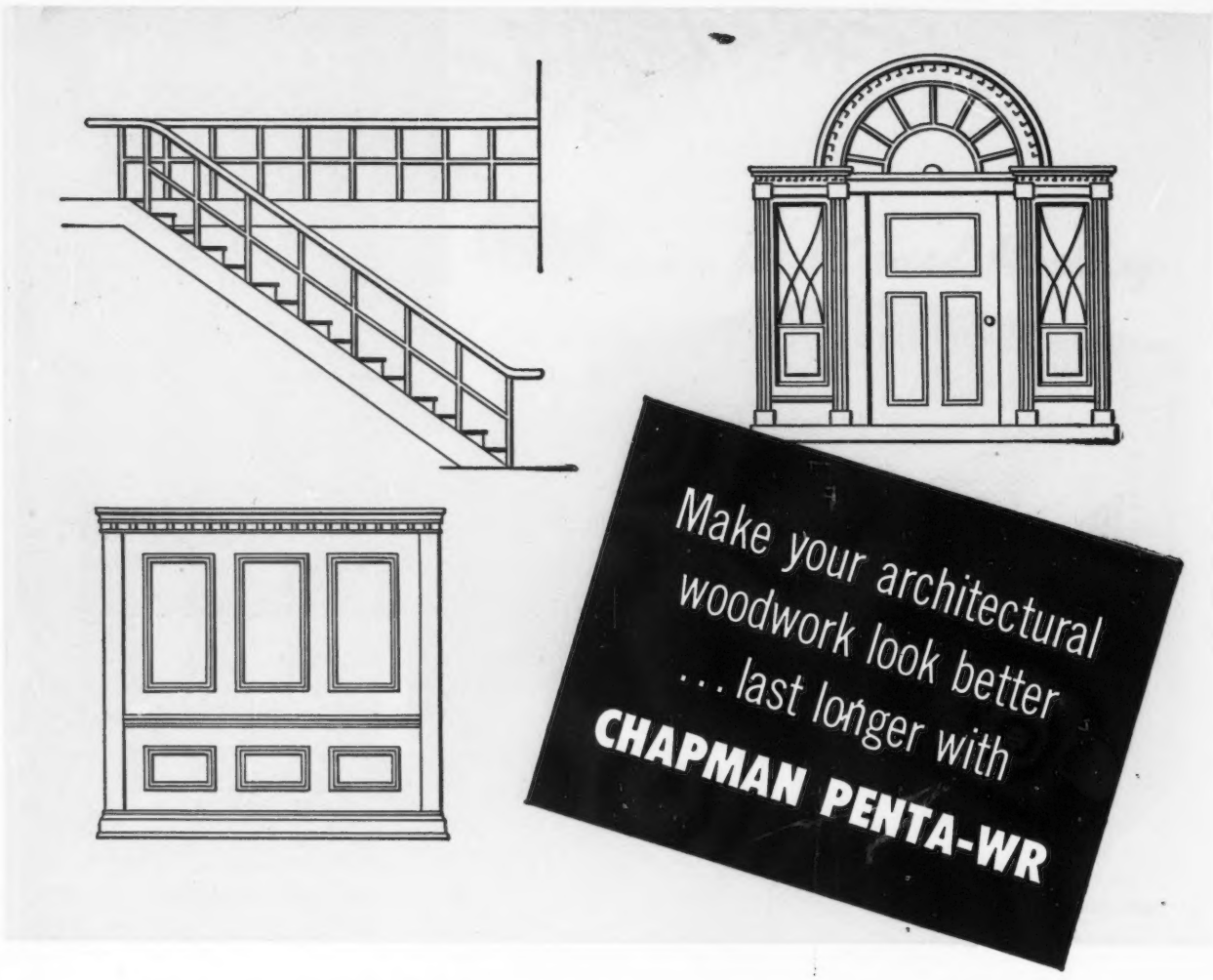

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IMPORTANT FPRS DATES

March 7–8: Eastern Canadian Section Annual Meeting, Queens Hotel, Montreal, Que.

April: Carolinas–Chesapeake Section, Clemson, S. C.

May 2–3: Northern California Section Meeting, Berkeley, Calif.

May: Florida–Georgia–Alabama Section Meeting, Talladega, Ala.

June 24–28: Eleventh National Meeting, Hotel Statler, Buffalo, N. Y.

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FPRS NEWS-DIGEST

Volume VII JANUARY, 1957 Number 1

Teco Sponsors International Particle Board Conference

Production processes, markets, and economics of wood particle board featured the second international conference in Washington sponsored by Timber Engineering Co. The two-day meeting last month climaxed the second year of special surveys and studies of wood residue utilization techniques used in Europe and America, with emphasis on particle board, conducted by the Teco laboratory for a group of lumber, particle board, and wood-using industries of this country.

Attending the meeting were some 75 representatives of Teco clients and interested industries, scientists, engineers, and producers of chemicals and specialized equipment used in manufacturing the new material.

. The first day's sessions featured reports by seven Teco utilization specialists. Dr. N. V. Poletika, Teco's Director of Research, presided at the sessions which included reports on foreign and domestic survey findings, ranging from properties and patents to processes, equipment, and industry economics.

The second day's sessions were devoted to open forums of representatives of U. S. and foreign engineering firms and equipment manufacturers specializing in the wood particle board field. Forum leaders were J. B. Veach, president, Bemis Hardwood Lumber Co.; Dr. H. B. McKean, director of research, Potlatch Forests, Inc.; F. W. Bottorff, president, Swain Industries, Inc.; G. V. Chapman, assistant manager of production, Drexel Furniture Co.; and Clark C. Heritage, consultant.

OPENING FORUM SERIES at international conference on wood particle board at Timber Engineering Co. was Carl A. Rishell, Teco vice-president. European and U. S. equipment manufacturers' representatives were among participants.

Woodworking Machinery Show Scheduled for May 1958

An extensive industrial exhibit, to be known as the American Woodworking Machinery and Equipment Show, will be held in May 1958 in Winston Salem, N. C. The show will be sponsored by the Woodworking Machinery Manufacturers Association in conjunction with the Southern Furniture Manufacturers Association.

The show, first of such working exhibits to be held in the South, will include all types of wordworking machinery and equipment for industrial purposes, as well as sawmills, veneer presses, and gluing equipment. Machinery users will be able to see in action the latest equipment for their particular fabricating requirements.

According to information released by Russell F. Hall, Jr., chairman of the show planning committee, exhibit space will be available to all American manufacturers of woodworking machinery and equipment and to other suppliers to the furniture and wood-using industries.

Particle Board Handbook Published by N. C. State

Latest information on wood particle board is provided in a 300-page handbook recently published by the Industrial Experimental Program, N. C. State College, Raleigh. The handbook was edited by Prof. E. S. Johnson, head of the Furniture Manufacturing and Management curriculum, and compiled by R. A. McLean, A. A. Carlyle, and L. B. McGee, staff members of the Industrial Experimental Program.

The publication discusses in detail the various manufacturing methods and machinery used in the production of wood particle board. Other major aspects considered are the forms and types of raw materials used, marketing, and product properties. Also included is a bibliography of current literature on the subject.

Copies of the handbook may be obtained for $3 each from Industrial Experimental Program, N. C. State College, Raleigh, N. C.

Forest Research Center Planned in Oregon

Forest and wood industries in Oregon will benefit from a new research center to be built this year in Corvallis, Ore. The Forest Products Laboratory will share facilities with the Forest Lands Research Group now in Salem, thus facilitating cooperation with the School of Forestry, Forest Experiment Station, and other divisions of Oregon State College.

The building will be located adjacent to the OSC campus. With 40,000 square feet of floor space in a 2-story

OPEN HOUSE GUESTS at ceremonies at National Starch Products' recently acquired Granite Board plant at Goffstown, N. H., included Senator Styles A. Bridges (second from right) and L. A. Whittemore, Chairman of the Board, Brown Co., Berlin, N. H. They are shown with Frank Greenwall, President of National Starch Products (right) and Herbert Hermsdorf, President of Granite Board, Inc. (second from left).

office and wing and two single-story research wings, ample room will be available for all departments of the Laboratory and Forest Lands group.

Borden Granted Rights to Fischer Formaldehyde Process

Exclusive rights to the Karl Fischer formaldehyde process have been granted to the Borden Co. Chemical Division, according to A. R. Marusi, Division president. Under the contract with Fischer's West German firm, Borden's may also license other producers.

The new system will provide an increased yield, it is reported, and lower utility and steam requirements for processing. A 93 per cent yield is anticipated, compared with the national average of 82 to 88 per cent. Borden's uses formaldehyde in manufacturing synthetic resins and also sells it commercially.

Oregon Woods Tested for Use as Railway Ties

Eight tree species are being tested on mainline railroad tracks in Oregon and three other western states in an effort to find a less expensive wood with as long or longer service life than the 40-year average span of Douglas fir, most commonly used species in the West for ties. Mountain hemlock, sitka spruce, lodgepole pine, western hemlock, Shasta red fir, Douglas-fir, incense cedar, and white fir are subjects of a cooperative study by the Oregon Forest Products Laboratory and Southern Pacific Co.

Robert D. Graham, senior research associate, heads the project for the Oregon Lab and R. M. Alpen, manager of Southern Pacific's wood preserving plants, represents the railroad.

Test ties were installed in 1952 at three locations in company tracks. In the third inspection in 1956, Graham reported incense cedar ties were in the best condition, followed by white fir and Douglas-fir. The researchers will need data from at least 10 annual inspections in order to predict serviceability of the ties.

Marketing Specialist Addresses Machinery Manufacturers Meeting

Clyde S. Gischel, Director of Marketing of the Stanley Works, New Britain, Conn., was the feature speaker at the Woodworking Machinery Manufacturers Association meeting held last month in New York City. In his talk on "Management's Responsibility to the Salesman," Gischel drew from his more than 20 years' experience in the selling field.

The group also heard Frank W. Schiff, Chief of the Domestic Research Division, Federal Reserve Bank of New York, speak on "The Business Situation".

C. S. Gischel

C. S. Walters

Log Grading Systems Compared in Study

Three grades apparently are enough for sorting hardwood logs into quality classes, it was concluded following a recent study of the log grading systems developed by the U. S. Forest Products Laboratory and the Purdue University Dept. of Forestry and Conservation. Profs. C. S. Walters of the U. of Illinois and A. M. Herrick of Purdue collaborated in the study.

Walters and Herrick report that the two systems generally agreed in their rating of poor-quality and high-quality logs, but they found less agreement in the grade assigned to medium-quality logs. Methods of predicting dollar value of the lumber cut from each log included: FPL log grades and accompanying lumber grade yields in per cent; Purdue log grades and percentage grade yields; and Purdue grades and quality indexes.

A complete report of the study, "A Comparison of Two Log Grading Systems," may be obtained from the College of Agriculture, Urbana, Ill., or from Purdue University, West Lafayette. Ind.

Graduate Fellowships Available at Syracuse College of Forestry

Research fellowships, scholarships and assistantships for the 1957–58 college year are available at State University of New York College of Forestry, Syracuse. The grants may be used for graduate study in 15 fields of forestry and forest products. Further information and application forms may be obtained from the Associate Dean of Graduate Studies.

Montana University Plans Forest Products Laboratory

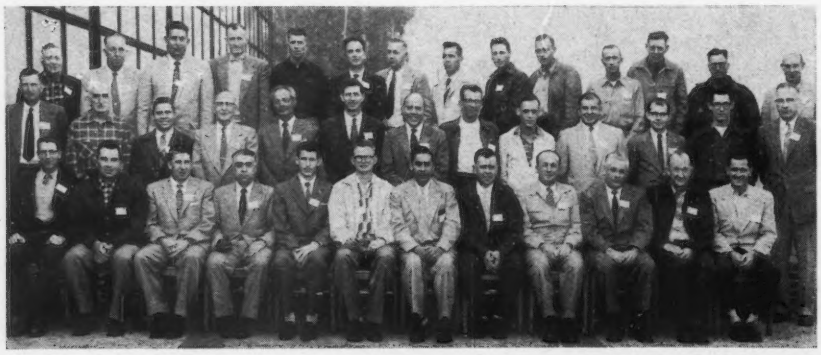
Missoula area logging and lumbering industries have volunteered to supply the funds for the basic engineering needed to set up a proposed forest products laboratory at the School of Forestry, Montana State University, according to President Carl McFarland. Forestry Dean Ross Williams said the services of Timber Engineering Co. will be engaged to draw preliminary plans and equipment specifications.

The laboratory is urgently needed to meet the increasing demand of industry for graduates trained in wood utilization, according to Dean Williams. Dr. John P. Krier, associate professor of forestry, will direct the new laboratory.

Pre-Assembled Wall Panel Studies Being Continued

A grant of $12,500 has been given the U. of Illinois to assist the Small Homes Council in continuing its studies on pre-assembled wall panels. Sponsors are the Lumber Dealers Research Council, which gave the original grant which led to the development of the panel system for exterior walls in 1953–54.

Objective of the continuation studies will be to effect savings in material and thus lower costs. They will include engineering analyses of structural requirements of exterior wall panels, design development based on these analyses, and modification or adaptation of the system to meet special conditions and permit the use of a variety of building materials.



LUMBER DRYING COURSE, first of its kind sponsored by U. of California Forest Products Laboratory, attracted registrants from California pine, fir, and redwood regions, with guests from Arizona, Brazil, and Iran. The course was held Dec. 10–15 in cooperation with U. S. Forest Products Laboratory and California Forest and Range Experiment Station.

Tentative Program Announced for National Meeting

Committee Arranging Interesting Program for Registrants and Families

An action-packed week is in store for registrants at FPRS' Eleventh National Meeting June 23–28 in Buffalo, N. Y., according to the tentative program announced this month by General Chairman Charles R. Lockard.

C. R. Lockard

The Hotel Statler will be headquarters for the meeting.

The program has been planned to provide profitable, pleasant periods for the dissemination of the latest basic and applied research results to all members and guests, whether they are logging superintendents, rough mill foremen, heads of finishing departments, paper makers, owners, managers, research directors, teachers, technicians, or industry suppliers. Chairman Lockard reports that the Committee is planning to provide something of interest each day for every registrant, as well as enabling them to pursue any special interests.

The schedule of activities shows 13 technical sessions, 14 subject matter division meetings, and 3 committee meetings, as well as a wide range of entertainment for the entire family. A primary attraction will be the Wood Industry and Suppliers Exhibit to be held in conjunction with the meeting.

Registration Starts Sunday

Registration, informal gatherings, committee meetings, and a "get-acquainted" reception on Sunday, June 23, will signal the start of the week's activities. Registration will start at 1 p.m. Sunday, June 23, and continue daily through Thursday. Fees have been set at $8 for members, $12 for non-members, and include admission to all technical sessions, division and committee meetings, and the Paul Bunyan Smorgasbord and Tour. Ladies registration fee is $5.

The Wood Industry and Suppliers Exhibit has been planned to show new developments in materials, equipment, and services which can reduce costs and increase production. Educational as well as commercial displays are being arranged, with the Exhibit to be open daily throughout the meeting.

The reception Sunday evening will be sponsored by the Northeast (host) and Eastern Canadian (cooperating) Sections. Meetings are also scheduled that evening for the National Employment, Publications, and Membership Committees.

A total of 14 Subject Matter Division meetings are scheduled to be held concurrently on Monday morning. They will cover Logging, Chemical Utilization, Machining, Quality Control, Glues and Gluing, Drying, Packaging, Lumber Manufacture, Preservation, Finishing, Veneer and Plywood, Composition Board, Marketing, and Industry-Education. Specialists in these fields will discuss significant technical changes in their segment of the wood industry.

General Session Opens Meeting

The technical program will officially begin with the General Opening Session on Monday afternoon, June 24. President Ralph H. Bescher will address the registrants and two other major speakers will discuss broad national and international problems of interest to the entire industry. The Annual Business Meeting will be held and the 1957 Wood Awards, sponsored by Vance Publishing Corp., will be presented during this opening session.

Headquarters for FPRS' 11th National Meeting will be the Hotel Statler, Buffalo

The technical sessions will follow the proved pattern of presentation of new material, followed by valuable floor discussion. The following is the tentative line-up of the 12 half-day sessions: Tuesday: Glues and Gluing, Machining, Veneer and Plywood, Finishing; Wednesday: Logging, Composition Board, Preservation; Thursday: Chemical Utilization (2), Drying, Lumber Manufacture, and Quality Control.

The Official Luncheon will be held Tuesday noon, June 25, and the traditional FPRS Banquet is scheduled that evening. The latter will include dinner, door prizes, and entertainment.

Variety of Plant Tours

On Wednesday, arrangements have been made for registrants to visit industrial plants in the Buffalo area. These include the Carborundum Co., Kimberly–Clark Corp., and Wurlitzer Co. Many other woodworking plants

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ADVANCE REGISTRATION

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BUFFALO, NEW YORK—JUNE 24–28, 1957

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within a 200-mile radius of Buffalo will hold open house on Friday, following the formal meeting. There will also be opportunity to visit the new $4 million forest products laboratory at State University of N. Y. College of Forestry at Syracuse.

FPRS registrants and their families will be guests of wood industry suppliers Wednesday evening at the Paul Bunyan Smorgasbord and Tour. The smorgasbord will be served at Brocke Monument Park in Canada, and will be followed by an evening tour of Niagara Falls.

Several Events for Ladies

An interesting program is being arranged for ladies and children, and registrants are urged to combine pleasure with business and bring their entire family. A family coffee hour on Monday morning will give registrants' wives a chance to get acquainted while the formal business program is getting underway.

A fashion tea is being arranged for Tuesday afternoon, with a bus tour of Niagara Falls and Canadian shopping trip scheduled Wednesday afternoon. Thursday afternoon the ladies and children will visit General Mills, the world's largest flour-processing plant, where Betty Crocker will personally conduct the tour.

Tuesday evening, coincident with the Banquet, children will be invited to a box supper picnic at the Buffalo zoo. It is expected that baby-sitting services also will be provided throughout the week.

The Committee urges members to send in their advance registration early, to aid in planning events and assure good accommodations. Complete details will be sent all members in the near future. Members desiring to register now are invited to use the pre-registration form on page 7–A.

Pacific Northwest Section Starts Series of Meetings

A series of informal meetings are being held periodically in Vancouver, B. C. by the Pacific Northwest Section, according to Vice-Chairman R. W. Wellwood. The first meeting was held Dec. 4 at the Faculty Club, University of British Columbia.

Principal speaker was Arthur Koehler, Special Lecturer, U. of British Columbia, and former Chief, Division of Silvicultural Relations, U. S. Forest Products Laboratory. He gave an illustrated talk on "Wood in Crime Detection". Mr. Koehler assisted police authorities on several criminal cases while on the Laboratory staff, the most notable being the Lindbergh kidnaping.

Technical Program Plans Well Underway

Preliminary announcement of the tentative technical program for the Eleventh National Meeting has been made by Dr. Frank H. Kaufert, FPRS President-Elect and Program Chairman. The meeting will be held June 24–28 at Hotel Statler, Buffalo.

F. H. Kaufert

Chairmen of the 12 technical sessions are now formulating their programs and arranging for speakers. Many of the sessions will feature panel discussions on new developments in various phases of the forest products field.

According to Dr. Kaufert, a portion of the program is being geared to the interests of the furniture industry, since many U. S. and Canadian furniture manufacturing centers are located near Buffalo. All areas of wood research will be covered thoroughly, he said, with sessions planned on Glues and Gluing, Machining, Veneer and Plywood, Finishing, Logging, Lumber Manufacture, Composition Board, Preservation, Chemical Utilization, Wood Drying, and Quality Control.

Paint blistering, natural exterior wood finishes, wood fillers, and color control in furniture finishing are among topics to be discussed at the Finishing session. Representatives from the U. S. Forest Products Laboratory, three leading paint and varnish firms, and a paint production club will be speakers.

A panel discussion on developments in Wood Composition Board will highlight the session on that subject. Specialists in adhesives, marketing, production, and wood technology will be among panel members. Two technical papers will also be presented at this session.

Achieving more efficient forest utilization will be the principal theme of the Logging session. Experts from the Canadian, northern Michigan, and Pacific Northwest logging areas will speak on methods of attaining greater working safety, development of better power chain saws, harvesting hardwood residues, yarding with rubber-tired tractors, and integrated hardwood logging.

The Lumber Manufacture session will feature a panel discussion on quality control in the sawmill, with other technical papers also being arranged. Representatives of several leading lumber producers are expected to participate.

Four papers will be presented at the Quality Control session by specialists in furniture, sporting goods, and other wood products manufacturing.

Two technical papers and a panel discussion will be features of the Glues and Gluing session. Dielectric Properties of Resin Glues for Wood will be discussed by T. J. S. Cole and D. G. Miller of the Ottawa Forest Products Laboratory. D. B. Richards, Alabama Polytechnic Institute, will speak on End Gluing of Lumber. New Developments in Wood Gluing Processes will be the subject of the panel session.

Latest developments in important veneer producing regions of the country will be reported at the Veneer and Plywood session. New testing methods will be discussed and an analysis will be made of the panel products field.

A panel discussion on lumber stacking, use of stickers, and related problems will highlight the Wood Drying session. Panelists will include representatives from universities, kiln manufacturers, and government laboratories. Technical papers are being planned on effect of seasoning on strength properties, kiln drying gum cross ties, high temperature drying, and kiln drying economics.

Increasing developments in chemical utilization of wood has resulted in two sessions being scheduled. One general session on Chemical Utilization will cover charcoal production, pine gum chemistry, and properties and uses of levulinic acid. A session on Lignin Utilization will include papers on activated carbon from spent pulp liquor and dimethylsulfide and its derivatives, with other subjects also being arranged.

Machining particle board and wide belt sanding of wood parts and assemblies are among subjects being considered for the Wood Machining session, according to Chairman L. A. Patronsky.

The Wood Preservation session being arranged by Chairman Ira Hatfield is expected to include papers on new developments in preservatives, test methods, and proper methods of application for various end uses.

Regional Nominating Committees, National Chairman Appointed

President Ralph H. Bescher has appointed two Regional Nominating Committees and named Lester J. Carr, past president, as Chairman of the 1957 National Nominating Committee. The committees will submit slates of candidates for national offices to be voted on by mail ballot prior to the National Meeting in Buffalo.

The National Nominating Committee will select candidates for President-Elect and Vice-President for 1957–58, and at least eight candidates for the 1958 National Nominating Committee. Four of the latter will be elected, with the two immediate past presidents also to serve on this committee.

President-Elect Frank H. Kaufert will automatically succeed Mr. Bescher as President at the Buffalo meeting. W. Jeter Eason is currently serving as Vice-President. Members of the National Nominating Committee are: Mr. Carr, Robert D. Pauley, George A. Garratt, Clark C. Heritage, Fred Dickinson, and Edward G. Locke.

The regional committees will name candidates for three-year terms on the Executive Board, to represent the Northwest and Northeast regions. The positions are now held by John D. Ritchie, Douglas Fir Plywood Association, Tacoma, Wash.; and Charles R. Lockard, Northeastern Forest Experiment Station, Upper Darby, Pa. Mr. Lockard was named to the post in June 1956 to serve one year of the unexpired term of Frank Parrish, who resigned.

Named to the regional committees were: Northwest — R. D. Pauley, Chairman, K. G. Fensom, C. A. Rasmussen, D. L. Haynes, and John P. Krier; Northeast—Frank Parrish, Chairman, Paul Graham, C. F. Van-Epps, Col. J. H. Jenkins, and J. W. B. Sisam.

Northern California Section Announces Spring Meeting Plans

All phases of particle board production and marketing will be discussed at the spring meeting of the Northern California Section to be held May 2–3 at the Claremont Hotel, Berkeley. Robert M. Kuhn, Secretary-Treasurer, announces that the program will be divided into sections on Raw Materials and Their Preparation, Types of Particle Board and Methods of Manufacture, and Markets and Future Potentialities of the Particle Board Industry.

Speakers will include: Clark Heritage, Consultant and former Director of Research at Weyerhaeuser Timber Co.; L. N. Ericksen, California Forest and Range Experiment Station; Douglas Hunt, Western Pine Assoc.; Dr. Joseph Marian, California Forest Products Laboratory; D. R. Siep, Donald R. Siep Co., New York City; W. C. Smith, U. S. Plywood Corp.; Dr. George G. Marra, State College of Washington; and Wayne C. Lewis, U. S. Forest Products Laboratory.

A feature of the meeting will be a visit to the Forest Products Laboratory, University of California, to observe and discuss research in progress.

Several Firms Reserve Suppliers Exhibit Space

Nearly one-third of the available space has been reserved for the Wood Industry and Suppliers Exhibit to be held in conjunction with the Eleventh National Meeting June 23–28 in Buffalo, according to Exhibit Chairman Russell C. Deckert. Because of the keen interest being shown by wood industry suppliers, Chairman Deckert urges firms interested in reserving space to contact him now at State University College of Forestry, Syracuse 10, N. Y.

R. C. Deckert

The Exhibit will be located in the Hotel Statler, meeting headquarters, on the same floor and adjacent to the principal meeting rooms. It will consist of representative displays of raw materials and equipment used in the manufacture of wood products, offering FPRS suppliers and supporting companies an opportunity to display their products or services to meeting attendees.

Firms which had reserved a total of 24 booth spaces as of January 7 included:

Kennametal, Inc., Latrobe, Pa.
Mater Engineering, Corvallis, Ore.
Onsrud Machine Works, Chicago, Ill.
Peter Cooper Corp., Gowanda, N. Y.
National Starch Products Inc., New York, N. Y.
Wel-Dri Co., Memphis, Tenn.
Senco Products, Inc., Cincinnati, Ohio
Industron Corp., Newton Highlands, Mass.
Deluxe Saw & Tool Co., High Point, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Perkins Glue Co., Lansdale, Pa.
Adamson–United Co., Akron, Ohio
Timber Engineering Co., Washington, D. C.
Yates–American Machine Co., Beloit, Wis.
Moore Dry Kiln Co., Jacksonville, Fla.
Power Line Sales, Inc., Detroit, Mich.
Masonite Corp., Chicago, Ill.
National Casein of New Jersey, Riverton, N. J.

Industry Suppliers Sponsoring Smorgasbord and Falls Tour

Sixteen firms supplying materials and services to the wood industry have already signed up as hosts for the Paul Bunyan Smorgasbord and Tour, entertainment highlight of the FPRS Eleventh National Meeting June 24–28 in Buffalo, according to Joseph Coufal, Chairman for the event.

J. Coufal

Meeting registrants and their families will be guests of the sponsoring firms at a smorgasbord supper at Brocke Monument Park in Ontario on Wednesday, June 26. In the evening the group will tour Niagara Falls before returning to Buffalo.

Firms interested in assisting as sponsors of this event, traditionally a feature attraction of FPRS meetings, are invited to write Mr. Coufal at National Adhesives, 270 Madison Ave., New York, N. Y.

The list of sponsors as of Jan. 15 included:

Bahnson Co., Winston–Salem, N. C.
Bauer Bros. Co., Springfield, Ohio
Black Brothers Co. Inc., Mendota, Ill.
Cleworth Publishing Co., Cos Cob, Conn.
Hitchcock Publishing Co., Wheaton, Ill.
Masonite Corp., Chicago, Ill.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Pacific Lumber Co., Scotia, Calif.
Preston Woodworking Machinery Co., Ltd., Preston, Ontario
Simonds Saw and Steel Co., Fitchburg, Mass.
Soderhamm Machine Mfg. Co., Talladega, Ala.
Southern Screw Co., Statesville, N. C.
Synvar Corp., Wilmington, Del.
Wilco Machine Works, Inc., Memphis, Tenn.
Williams Patent Crusher and Pulverizer Co., St. Louis, Mo.
S. A. Woods Machine Co., Boston, Mass.

Ohio Valley Section Plans Five Round-Table Discussions

Five round-table discussions of practical methods of solving various wood technology problems will be features of the Spring Meeting of the Ohio Valley Section to be held April 11 and 12 at the Kentucky Hotel. Louisville, according to Chairman John H. Wilson. This will be the first FPRS meeting of its type, with the entire program consisting of group interchange of ideas.

Keynote speaker at the opening session Thursday afternoon, April 11, will be C. D. Dosker, President, Gamble Brothers, Inc. Chairman Wilson will preside and the moderators will outline the subjects to be covered in the group discussions.

Topics to be discussed are: lumber

drying and handling, carbide tools, jigs and fixtures in woodworking, particle board and wood cores, and glues and gluing. Panel members, representing industries and laboratories from throughout the country, will share their knowledge and experience in helping solve problems of members and guests in these fields.

The program committee has scheduled a "Sawdust and Chips Hour" Thursday evening and group luncheon on Friday. A tour of H. J. Scheirich Co. will conclude the program.

Officers Named at F–G–A Section Annual Meeting

Rufus H. Page, Forest Utilization Service, Macon, Ga., was elected Chairman of the Florida–Georgia–Alabama Section at their annual meeting held Dec. 7–8 in Athens, Ga. Other newly elected officers are: Windell Vickery, Vice-Chairman; Ralph Peter, Secretary; and Ben Turner and Ray Osborne, Trustees. The meeting on Hardwood Utilization attracted a registered attendance of 56 persons. Among those present was Ralph H. Bescher, National President of FPRS.

Tentative plans were made for a spring meeting of the section to be held the last week in May in Talladega, Ala. Soderhamn Machine Manufacturing Co. will serve as host for the one-day meeting, which will consist of a debarking, chipping, and log handling show. Gus Jacobson, Section Trustee and president of the firm, will demonstrate Soderhamn equipment. Demonstrations will also be held at other plants within a 25-mile radius of Talladega.

Subjects discussed at the December meeting included: Improved Hardwood Pulping Techniques and Processes, Weight/Volume Relationship of Wood and Residues, Developments in Debarking and Chipping, Merchandising Chipcore and Veneer, and Paper Overlay Lumber and Parquet Flooring. The meeting also included a panel discussion on Wood Paneling and a tour of the Athens–Macon Research Center facilities.

Summer Employment Program in High Gear

The FPRS Student Summer Employment Program is off to a good start in 1957, with 30 colleges and universities and 45 firms already indicating a desire to cooperate. The program, now in its second year, is under the direction of Dr. Newell A. Norton, School of Forestry, Penn State University, Chairman of the FPRS Employment Committee.

N. A. Norton

The program enables wood industries to secure temporary summer employees and gives forestry and wood technology students an opportunity to gain on-the-job experience which will be beneficial to them and their employers when they seek permanent positions upon graduation. Industries also report the program aids them in recruiting permanent employees. The summer training period gives an opportunity for evaluating the student's aptitudes and ability, while the students gain insight into the company's operations which may be a factor in deciding job offers upon graduation.

Assisting Dr. Norton in coordinating the program are: Roy M. Carter, N. C. State College, Raleigh; Eldon M. Behr, Chapman Chemical Co., Memphis, Tenn.; Harvey H. Smith, California Forest and Range Experiment Station, Berkeley; Richard W. Pettersen, St. Paul and Tacoma Lumber Co., Tacoma, Wash.; and E. R. Martell, Purdue University, Lafayette, Ind.

Committee members are contacting wood industries in their region to determine their interest in obtaining student employees this summer. These lists of interested firms are sent to schools within the geographic area to give them first opportunity at filling local jobs. The lists are subsequently distributed to schools throughout the country.

Companies desiring to participate in this year's program are urged to contact the committee member in their region or the FPRS National Office, Box 2010, University Station, Madison 5, Wis. Students seeking summer employment should get in touch with their faculty representative or the FPRS Office.

To date, 30 schools have reported a total of 195 students seeking summer jobs and 45 firms have expressed interest in hiring one or more employees under the program. In 1956, first year of the program, 42 schools were contacted but returns were incomplete on the number of students using the service. Ten schools reported a total of 63 students interested, 16 of which obtained summer jobs. A total of 78 firms offered to cooperate in the program last year.

Schools Cooperating

This year forestry schools and departments at the following colleges and universities are actively participating in the program:

Northeast: U. of Maine, Orono; U. of Vermont, Burlington; U. of New Hampshire, Durham; U. of Massachusetts, Amherst; Yale U., New Haven, Conn.; State U. of New York,

MEMBERSHIP PROGRAM of F–G–A Section is discussed by President R. H. Bescher (left) and Section Chairman Rufus Page.

NEW CHAIRMAN of F–G–A Section is Rufus Page (second from right), being congratulated by Past Chairman J. B. Huffman. At left is LeRoy Rand, retiring Secretary–Treasurer, and right is Ralph Peter, Rand's successor.

WOOD PANELING was discussed at Athens meeting by, left to right, Carl Wheeler, Georgia–Pacific Plywood Co.; Fred Bowlin, Atlanta Oak Flooring Co.; Ralph Peter, U. S. Forest Service; and D. B. Richards, Alabama Polytechnic Institute.

Syracuse; Rutgers U., New Brunswick, N. J.; Penn State U., University Park; Laval U., Quebec; U. of Connecticut, Storrs.

Southeast: U. of Florida, Gainesville; N. C. State College, Raleigh; West Virginia U., Morgantown; Duke U., Durham, N. C.; Virginia Polytechnic Institute, Blacksburg.

North–Central: Iowa State College, Ames; U. of Michigan, Ann Arbor; Michigan State U., East Lansing; U. of Minnesota, St. Paul; Purdue U., Lafayette, Ind.

South–Central: Alabama Polytechnic Institute, Auburn; Louisiana Polytechnic Institute, Ruston; Louisiana State U., Baton Rouge; Oklahoma A & M College, Stillwater; Stephen F. Austin State College, Nacogdoches, Texas.

Northwest: U. of British Columbia, Vancouver; U. of Idaho, Moscow; Montana State U., Missoula; Oregon State College, Corvallis; U. of Washington, Seattle.

Southwest: U. of California, Berkeley; Colorado A & M College, Fort Collins.

Participating Companies

Firms that have offered to hire students this summer include:

Northeast: Protexol Corp., Kenilworth, N. J.; Armstrong Cork Co., Lancaster, Pa.; Osmose Wood Preserving Co., Buffalo, N. Y.; Heywood–Wakefield Co., Gardner, Mass.; Brown Co., Berlin, N. H.; Jamestown–Sterling Corp., Jamestown, N. Y.; Fyles Co., Orwell, Vt.; Paramount Furniture Co., Warren, Pa.; Koppers Co., Pittsburgh, Pa.; Saunders Bros., Westbrook, Me.

Southeast: William Ritter Lumber Co., Roanoke, Va.

North–Central: Brunswick–Balke–Collender Co., Muskegon, Mich.; Hartzell Industries, Piqua, Ohio; General Box Co., Louisville, Ky.; Edward Hines Lumber Co., Chicago; Consider H. Willet, Inc., Louisville, Ky.; Joslyn Manufacturing Co., Chicago; Wood–Mosaic Co., Louisville, Ky.; Mengel Co., Louisville, Ky.; Long–Bell International Paper Co., Kansas City, Mo.

South–Central: Southern Pine Lumber Co., Diboll, Texas; Berkline Corp., Morristown, Tenn.; Masonite Corp., Laurel, Miss.; International Paper Co., Mobile, Ala.; Dierks Forests, Inc., Mountain Pine, Ark.; East Texas Pulp and Paper Co., Silsbee, Texas; Long–Bell International Paper Co., DeRidder, La.; Southland Paper Mills, Lufkin, Texas.

Northwest: Snellstrom Lumber Co., Eugene, Ore.; Forest Fibre Products Co., Forest Grove, Ore.; Willamette National Lumber Co., Foster, Ore.; Medford Corp., Medford, Ore.; Western Pine Assoc., Portland, Ore.; Roseburg Lumber Co., Roseburg, Ore.; Georgia–Pacific Corp., Toledo, Ore.; J. Neils Lumber Co., Klickitat, Wash.; Borden Co., Seattle, Wash.; Reichhold Chemicals, Inc., Seattle; Seattle Door Co.; Simpson Logging Co., Shelton, Wash.; West Tacoma Newsprint Co., Steilacoom, Wash.; Douglas Fir Plywood Assoc., Tacoma, Wash.; Educators Manufacturing Co., Tacoma; Northwest Door Co., Tacoma; Ketchikan Pulp Co., Ketchikan, Alaska.

McKean Named Chairman of Inland Empire Section

Herbert B. McKean, Director of Research at Potlatch Forests, Inc., was elected Chairman of the Inland Empire Section at the January 17–18 meeting in Spokane, Wash. Other officers elected include: Vice-Chairman, Ross McNett, president, Biles – Coleman Inc.; Secretary-Treasurer, I. W. Wentworth, Northwest Timber Co.; and Board Members, Lawrence E. O'Neil, Forest Products Co., and Owen C. Sawyer, Peshastin Lumber and Box Co.

H. B. McKean

At the two-day meeting, Otto C. Heyer, U. S. Forest Products Lab, stated that uses of wood in new forms, such as molded and extruded items, can increase the consumption of wood. However, he added, it takes 10 to 20 years for a product to go from the laboratory to the acceptance stage.

Harding Townsend, regional sales manager for W. P. Fuller Co., demonstrated a clear latex interior and exterior finish that dried in 20 minutes. The importance of patenting not only processes but also materials was discussed by Greek Wells, Spokane patent attorney. Dr. A. W. Stout, research chemist for the Western Pine Association, discussed storing logs in dry docks.

The meeting also included a tour of the Long Lake, White Pine Sash, and Northwest Timber Structures properties in the Spokane area.

Carolinas–Chesapeake Section Elects Officers for 1957

John B. Veach, Jr. has been elected Chairman of the Carolinas–Chesapeake Section. Other officers are: James S. Bethel, Vice-Chairman; and Michael A. Taras, Secretary–Treasurer. The next Section meeting is scheduled in April in Clemson, S. C.

NEW PRODUCTS—LITERATURE

Sawmill Accessory Line

A broadening of its line of accessories to improve sawmill carriages already installed and to cut mill operating costs is announced by Mater Machine Works, Corvallis, Ore.

Engineered for installation on most makes of carriages, the accessories include: pantographs, steel devices for carrying air and electricity from mill floor to carriage which reportedly decrease maintenance costs and avoid breakdown lost time; air dog conversion kits; air operated flippers; setworks, either transition type for setter operation now, conversion to remote sawyer control later, or remote control pre-set setworks; air-operated bark blowers; track scrapers; and ASME code air tanks.

New Pole Carrier

A straddle, clam-shell-type pole carrier has been developed by J. Neils Lumber Co. in cooperation with the Hyster Co. of Portland, Ore. The manufacturer reports that with this carrier no bunks or other supports are needed to transport the poles, and there is no chance for spilling or damaging poles enroute.

Other features of the pole carrier are easier, quicker pickup of material that has fallen from piles or is in the road, and elimination of manual work of three men, according to H. C. A. Hunter, J. Neils treating division manager. He adds that the carrier has almost twice the carrying capacity of former loads.

Three Resin Adhesives

Three new adhesives for laminating work have been announced by National Adhesives Division, National Starch Products Inc., 270 Madison Ave., New York. All three may be applied by reserve roll or gravure application.

Resyn 36–6254 is formulated to laminate cellulose acetate butyrate to foil in the production of metallic yarn. It is a rubber based, light amber, transparent adhesive with a viscosity of 2500 cps. Boilable flexible containers are being made by laminating reverse

printed cellulose acetate to foil with Resyn 76–3930. Resyn 76–3944 is used for laminating Mylar to metallized Mylar or Mylar to foil. Drying temperatures of 200 to 250° F. with a "nip" temperature of 210 to 250° are recommended.

Hardboards Described

An illustrated booklet describing hardboard uses, physical properties, exterior and interior applications, and finishing recommendations is available from Forest Fiber Products Co., Box 68 S, Forest Grove, Oregon.

Entitled "Forest Hard Boards," the 12-page booklet discusses the product's workability, uniformity, surface, color, strength, and durability. The booklet also includes information about the following Forest Hardboards: standard, thriftwood, underlayment, temper-treated, tee-n-gee panels, forall, forestex, concrete form, and punched. Characteristics such as weather resistance, sound absorption, thermal conductivity, hygroscopic expansion, and impact strength are described for the various types of hardboard.

Cutterhead Bulletin

An illustrated catalog showing Wisconsin Knife Works' complete line of standard, special, and commonly used clamp T slot heads used on moulders and matchers is available from the manufacturer, Box 309, Beloit, Wis. Bulletin 200 describes milled-to-pattern bits and clamp T slot shiplap, eased, flooring, paneling, profile, and moulder heads as well as sleeves, collets and wrenches.

Dry Kiln Controller Series

A complete new series of dry kiln instruments has been announced by the Foxboro Co., Foxboro, Mass. The new instruments, with modern rectangular case construction for panel or surface mounting, embody the latest developments in controller design, plus the flexibility of application required by different type kilns, the manufacturer reports.

The new series includes both single-zone and multi-zone temperature-humidity recorder controllers. Single-zone units for small compartment kilns and multi-zone controllers for long compartment and progressive kilns are available with or without dual dry bulbs and duplex wet bulb control.

Narrow band proportional control is an optional feature said to be particularly useful in reducing damper whipping. Other features include color coding of pens, setting indices and knobs, control relays, output pressure gauges and other components.

NAMES IN THE NEWS

Rex V. Reynolds has been named manager of woodworking industry sales for Kennametal, Inc., Latrobe, Pa. He has been specialty products sales engineer for the firm during the last ten years. **Don A. Curtis,** formerly associated with Curtis Machine Corp., has joined the Kennametal firm and will assist Mr. Reynolds in the sales and application of carbide knives and cutting elements.

R. V. Reynolds

D. A. Curtis

Announcement has been made of resignation of **C. G. Monnett,** as Vice-President, Dependable Machine Co., Greensboro, N. C.

Election of **Leo V. Bodine** as vice president in charge of timber and lumber operations of the Diamond Match Co. has been announced by **R. G. Fairburn,** president. Bodine has served since 1952 as executive vice-president of NLMA and chairman of the board of Timber Engineering Co.

L. V. Bodine

G. Kitazawa

Dr. George Kitazawa has been named head of a new forest products research group for The Borden Company's Chemical Division at the firm's Central Research Laboratory, Philadelphia, Pa. He was formerly research physicist for the Gillette Co.

Dr. Herbert O. Fleischer was promoted to chief of the division of timber processing at the U. S. Forest Products Laboratory last month, upon the retirement of **Dr. T. R. Truax** after 38 years' service. Fleischer had been in charge of the Laboratory's veneer and plywood research since 1944.

H. O. Fleischer

J. M. Yavorsky

Dr. John Yavorsky has been appointed Chief, Forest Utilization Section, Forestry Division, Food and Agriculture Organization of the United Nations, with headquarters in Rome, Italy. Yavorsky, former specialist in electronic gluing research at State University of New York College of Forestry, Syracuse, will coordinate the UN's technical assistance program in the field of forest products utilization.

SALESMAN—INDUSTRIAL

Excellent opportunity to join expanding national chemical company. To sell structural adhesives and structural products. Indiana–Michigan territory. College grad to 32 years of age. Some selling experience. Salary $5000–$6000 a year to start plus expenses plus car. Write age, education, experience.

Send replies to:

E-267, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
P. O. Box 2010, University Station
Madison 5, Wisconsin

EMPLOYMENT SERVICE

Positions Offered

No. E–268—East Coast Naval Laboratory seeks wood technologists for New York City area. Salaries from $3,670 for recent graduates to $6,116 for experienced men. Work ranges from fundamental studies on foreign woods to diverse uses of wood in shipbuilding. (Jan.)

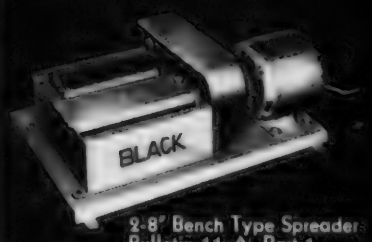
No. E–270—Specialty paper producer in Pennsylvania has opening for engineer experienced in paper production problems. Responsibilities include plant mechanization, introducing new paper products into production. Prefer mechanical engineer approx. 35 years of age. Salary $8,000 to $10,000. (Feb.)

No. E–271—Midwest millwork firm has opening for project engineer to be responsible for design and development of products. Needs man with B.A. in architecture or architecture engineering, interest in product design. Salary based on experience and ability; profit-sharing plan. (Feb.)

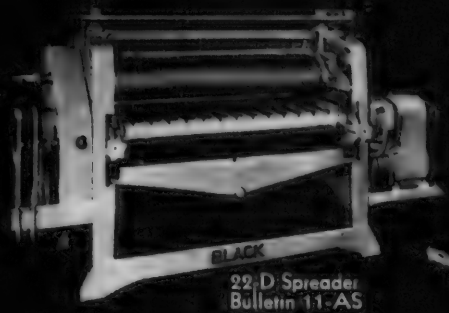
Employment Wanted

No. 401—Master of Wood Technology graduate, N. C. State College, B. S. in Forestry, V.P.I., desires research, quality control, or production position. Age 25, single. Veteran as of April 1957. (Feb.)

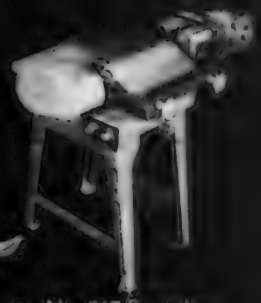
No. 403—Wood technologist — Ph.D., 12 years' experience in industrial pulp and paper research lab and government wood testing laboratory. Prefers moderately sized community in Eastern U. S. (Feb.)



2-8″ Bench Type Spreader
Bulletin 11-A, Part 1



22-D Spreader
Bulletin 11-AS


No. 567 Spreader
Bulletin 11-A, Part 2

First in Production, Quality, Economy

BLACK BROTHERS EQUIPMENT

. . . for gluing, clamping, laminating

GLUE SPREADERS

The most complete line in the world—for hot or cold glues. Single or double spreaders from 8″ through 122″ roll widths.

GLUE MIXERS AND HEATERS

Cold Glue Mixers—10 to 400 gal.; Portable Motor Driven Cold Glue Mixers—2 to 15 gal. Glue Heaters for steam, electric or gas heat—2½ to 125 gal.; Portable Pot Glue Heaters.

COLD PRESSES

A wide line of high-production presses: Rotary-type; Air-Hose; Electric, Hydraulic and Hand Power Laminating Presses. Efficient, accurate, economical.

PRODUCTION CLAMPS

A production clamp for every need: Case Clamps—hand-powered or pneumatic, revolving or stationary; Clamp Carriers; Sash, Frame and Door Clamps.

THE BLACK BROTHERS CO., INC.

MENDOTA 8, ILLINOIS

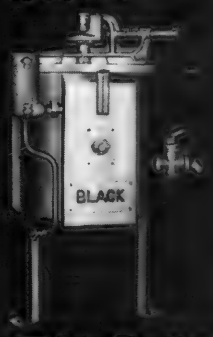
Case Clamp
Bulletin 11-J

Cold Glue Mixer
Bulletin 11-I

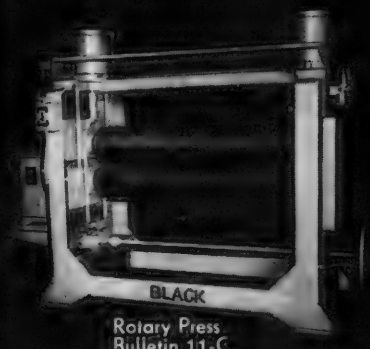
Clamp Carrier
Bulletin 11-K

Portable Glue Mixer
Bulletin 11-IS

Sash, Frame and Door Clamp
Bulletin 11-M



No. 700 Series Glue Heater
Bulletin 11-H



Rotary Press
Bulletin 11-C

Motorized Laminating Press
Bulletin 11-E

Air Hose Laminating Press
Bulletin 11-D

FPRS Supporting Member Opens New Dry Process Board Plant

A dry process shaving board being manufactured by Columbia Hardbord Co. at Everett, Wash., increases log utilization to nearly 100 per cent, according to company officials. The firm is a subsidiary of Columbia Plywood Co., FPRS Company Supporting Member since 1955.

F. L. Johnson

F. L. Johnson, president of Columbia Plywood Co., is a national leader in dry process utilization. Previous to his association with this firm, he was general manager of Anacortes Veneer, Inc. During this time, the firm undertook construction of the first dry process hardboard plant, which was designed to make use of wastes from veneer manufacturing. Dry process panels produced were found to be competitive with the wet process in both strength and durability.

Joining the Columbia Plywood firm as president in 1951, Mr. Johnson was instrumental in directing expansion of the company's plywood plant at Kalama, Wash. In 1953, the need for quality panels in all plywood thicknesses and manufactured from wood waste became more apparent. The company then retained the services of Dale L. Schubert of Industrial Development Co., Inc., and continued to underwrite development and cost studies of a panel exceeding 3/8 inch in thickness. Mr. Schubert presented the company with a process and design for a high flexule strength, three-layer flake panel in early 1955.

Columbia Hardbord Co. was formed and in October 1955 construction began on a new panel plant at Everett, selected for its central Puget Sound location and proximity to abundant sources of wood waste. The plant is now producing Cedawood, brand name for the dry process panel produced from western red cedar waste.

D. L. Schubert

D. Johnson

With high MOR and minimum glue absorption when overlayed, the new product is designed as an underlayment for hardwood veneer and plastic laminates. The panel is reported ideally suited for prefabricated industries. Polyester protective coatings go on easily and form a tough, resistant surface. Because of the excellent nail-holding properties close to the edges and its ability to be easily sanded or machined, Cedawood is said to be adaptable to a wide variety of woodworking operations.

Sales manager for the Columbia Hardbord Co. is Donald Johnson, with Columbia since 1949 and the firm's designated representative to FPRS. Information and sales for the products are handled through the company's Seattle office, 560 Skinner Building.

Meet FPRS 100 Company Supporting Members

ALABAMA
W. T. Smith Lumber Co., Chapman

ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Mountain Pine
Southern Lumber Co., Warren

CALIFORNIA
California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
High Sierra Pine Mills, Inc., Oroville
Ivory Pine Co., Dinuba
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene

ILLINOIS
The Dean Company, Chicago
General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
Steger Furniture Mfg. Co., Steger

INDIANA
Kitchen Maid Corp., Andrews
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
The Wood-Worker & Veneers and Plywood, Indianapolis

IOWA
Curtis Co. Inc., Clinton

MARYLAND
J. I. Wells, Salisbury

MASSACHUSETTS
Draper Corp., Hopedale
Heywood-Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven

MINNESOTA
Mereen-Johnson Machine Co., Minneapolis
Minnesota Mining and Mfg. Co., St. Paul
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis
Winton Lumber Co., Minneapolis

MISSISSIPPI
Richton Tie and Timber Co., Richton

MISSOURI
Monsanto Chemical Co., St. Louis

MONTANA
Intermountain Lumber Co., Missoula

NEVADA
Vaughn Millwork Co., Reno

NEW JERSEY
National Adhesives, Plainfield
Western Electric Co., Kearny

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
The New England Industries, Inc., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., New York
The Upson Co., Lockport

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
American Machine & Foundry Co., Shelby
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati

OREGON
Brooks-Scanlon, Inc., Bend
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Kennametal, Inc., Latrobe
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Wynnewood Products Co., Jacksonville

VERMONT
Beecher Falls Mfg. Corp., Beecher Falls

WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long-Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

WISCONSIN
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co. Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

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Wood Particle Molding[1]

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Reviews wood particle molding process and lists requirements for application of the process to various products. Relation of process variables to strength and related properties of the molded article is discussed. Equipment needs and finishing operations are described and growth of the industry is summarized.

Introduction

MANY PRODUCTS MANUFACTURED of wood are of irregular shape and there is a considerable amount of wood removed in finishing. This cut away wood is mostly waste and costs the manufacturer money in raw materials and labor. These facts are a major reason for the existence of a relatively new industry—that of molding wood particles into finished or nearly finished wood-like shapes.

This is an industry which is laden with contradiction, even in its reason for being, because the basic raw material used in wood particle molding is wood flour, which is derived from the manufacture of some of the very articles the new industry is striving to replace. This contradiction might be the ultimate limitation on the growth of the wood particle molding industry, but it is not likely to be the cause of its death. Raw materials will be abundant even if the molded product replaces all of the wood articles to which the molding process is suited. There are a number of reasons why this is true:

1. The number of wood articles that may be replaced by molded wood products is limited by the economics and properties of the molded wood product.

2. The waste accumulation from other type wood articles is so large that the amount currently used in wood particle molding is almost a negligible percentage.

3. The process of molding to shape eliminates or bypasses so many labor operations that the industry is in a favorable position to meet the market price of either ground wood or the material from which to grind wood flour.

Furthermore, the use of the phrase "replace wood products" is ambiguous. Its use is correct in that it will replace the method of using wood in some cases, but the molded product actually uses as much or more wood than an equivalent product made of lumber in the conventional way. The raw material used in the wood particle molding process is a by-product of wood manufacture which might otherwise be valueless. New uses for this wood by-product give it value, which in turn reduces costs on the primary wood article.

In the long run, this molding process may serve the wood industry to regain, or to keep from losing, markets for products which might be lost to sheet steel, plastics, or other materials. So instead of saying that this new product replaces wood, it is better to think of it as a new tool for the wood industry and a new outlet for wood by-products.

Description of Process

Wood particle molding is basically a process in which a blend of wood particles and adhesives are pressed into shape in a mold, in such a manner that the individual particles of wood do not lose their identity. This definition is purposely general, to allow for growth and development in the new industry, but it does place a dividing line between wood flour molding and plastics molding where wood flour is used as a filler.

To be more specific, the process as it is known today consists of mixing particles of wood with an adhesive (usually a powdered phenol formaldehyde resin), introducing the mixture into the cavity of a heated mold, and

[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

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Fig. 1a.—Filling mixer with weighed materials from storage mezzanine at C. F. Church plant.

Fig. 1b.—80 cubic foot ribbon blender.

pressing it there hydraulically until the thermosetting reaction of the resin is completed. The mold is then opened and the part removed, ready for finishing.

Why Mold Wood Waste?

Now the question arises: Why mold articles of wood particles? Why not fabricate or shape these articles out of wood? Why not mold them out of some conventional plastic material? Why not use metal castings, sheet steel, or aluminum? The answer is no different from the answer to the same questions on any material selection. A material is chosen to do the job at the lowest cost. Wood particle moldings are a material that have a place and can do the job in some applications.

In order to use wood moldings, these requirements have to be met: It has to have a shape that can be molded. It has to be made at a lower cost than it can be made of some other suitable material. It has to be made in large enough volume to amortize the tooling costs at a reasonable rate per piece. It has to be an article where the properties of molded wood will perform satisfactorily. These requirements will be discussed further in the order named.

Molded Shapes

Not all shapes can be molded from wood particles. For instance, it would be virtually impossible to mold a box or a flower pot. These parts can be fabricated from segments made of molded wood particles, but they cannot be molded in one piece. The reason is that the molding of wood particles is not strictly a molding operation at all; it is essentially a pressing operation. The nature of this material is such that it has very little flow during molding. Consequently, the material must be predistributed prior to closing the mold. This type of mold loading is so difficult that it is almost impossible in such high-walled parts as the aforementioned box and flower pot.

Parts which can be easily and satisfactorily molded of wood particles are reasonably flat, do not have abrupt and great changes in cross section, and do not have large thin areas. It is not possible to specify these qualifications too exactly. Some degree of unsuitable design may be overcome with careful molding procedure, or in some cases where the specifications of the molded part do not call for exceptional strength or uniform appearance and density, they may be ignored. However, abrupt changes in cross sectional thickness will usually result in varying appearance and strength in the molded part, because of the difficulty of proper placement of the load so that it will press to a uniform density.

Thin areas in an otherwise thick part cause another type of molding problem. Material caught between the force and cavity in a thin area builds up to a very high density, retarding the closing of the mold. If the mold closing is retarded long enough, the adhesive in the thin area polymerizes completely, binding the material into a solid mass. This either prevents the mold from closing or if the mold does close, the thin area is permanently crushed.

Economics

Because an article can be molded does not mean that it should be manufactured from molded wood particles. It may cost less to fabricate out of wood or to mold out of plastic or some other method of manufacture.

In comparison to even the least expensive of plastic molding materials, the wood particle-adhesive mixture is cheap. In plastics, excluding foamed and cellular grades, $10 per cubic foot is a low material cost. An average wood particle molding mix molded to a 1.0 specific gravity, costs about $3 to $4 per cubic foot, about the price of kiln-dried birch lumber.

In lumber, the cubic foot price goes up in progression as the lumber is planed, sawed, jointed, and shaped. Almost all of the raw material for wood particle molding, like plastic molding materials, ends up in the finished piece. On this basis the wood particle raw material is decidedly less expensive than plastics and certainly no more expensive than a good grade of lumber. Where the part is large enough for material cost to outweigh production time, and where the properties of the wood particle molding will satisfy the specifications, the economics, at this point, have already eliminated plastics as a competitive material.

When compared with wood, any economic savings of molded wood particle parts have to be on the basis of reduced labor costs to produce a given part. For wood parts, the labor is primarily a function of the shape of the part, but in molding, the molding operation takes about ½ to 1 minute of manual labor for almost any part, irrespective of shape. This is the normal time consumed in preparing the mold charge, unloading, cleaning, loading the mold, and actuating the molding press. The actual labor time is influenced to some degree by the amount of mechanization with which the job is set up, the design of the part, and by the number of parts grouped in the mold.

At the end of the molding operation, the part is in the shape predetermined by the mold. Any subsequent operations would have a counterpart in wood operations on the same part and the time, methods and costs are comparable.

With this information, it is possible to make labor cost comparisons of wood particle moldings and woodwork in a general way, if we know the labor costs involved in woodwork. Specific comparisons are not possible in this paper, but in general, if 25 per cent of the wood has to be cut away in the woodwork, molding will be lower in labor cost than in the natural wood product.

Equipment

The third requirement for a molded wood particle application is large volume production of identical parts. This is related to the cost of equipment for the molding operation. The major equipment required for a wood particle molding operation includes: 1) hydraulic presses, 2) mixing equipment, 3) molds, and 4) high-pressure steam boilers. These are expensive pieces of equipment and probably represent a higher capital investment for a given daily output than standard woodworking. machines.

For a woodworking plant, this equipment might not be as versatile as most woodworking equipment, because the applications for wood particle moldings are limited. In a plastic molding plant, this situation is entirely different because, with the exception of the mold, the major apparatus is standard equipment and can safely be amortized over a long period of time. This is one reason for an earlier statement that wood molding is more closely allied with plastics molding than with woodworking.

Actual equipment costs for molding wood particles are relative to the size of the operation being set up. It is understandable that, because some equipment is essential in any size operation, the capital investment compared to output decreases as the size of the operation increases. However for the purpose of giving some general cost figures, let us assume an operation of six average size presses. This unit would produce approximately 900 one-inch thick parts that are up to 2½ square feet in area in a 24-hour day. Thinner parts would increase the output but smaller parts in area will increase the output only insofar as multiple cavity molds will fit in the press.

The six presses for this assumed unit would cost about $30,000. Pumping equipment, valves, piping, wiring and cycle timers would cost about $2,000. Six molds would cost approximately $20,000. Mixing equipment

would cost another $4,000. Exhaust fans and duct work would add another $2,000. With other miscellaneous equipment, this represents a capital investment of about $60,000. or $10,000.00 per press.

The floor space requirement for this unit would be about 1,000 sq. ft. for the presses and mixers and another 750 square feet for storage of the raw materials—wood flour and resin adhesive. Space for finishing operations would be another addition of floor area.

Power consumption would be approximately six boiler horsepower of high pressure steam (120 to 150 psi) and 30 horsepower of electricity.

These figures will give a rough idea of the capital investment. It should be clear that a large and continuous quantity of identical parts is required to justify the molding of wood particle parts if cost is the only consideration. However, if the operation is large enough and the part is suitable for molding as otherwise described, the cost of molding the part will be 1/3 to 2/3 the cost of a natural wood part.

Furthermore, there are some parts which, from a design standpoint, could not even be considered in woodwork because of cost but are readily molded from wood particles. And in addition, there are parts where the properties of the molded wood particles can be made to be more suitable for the application than those of wood.

—Photo by Bakelite Co.

Fig. 2.—Laundry hamper lid is molded from mixture of sawdust and phenolic resin (top) in Meehanite mold (bottom left) under about 700 psi pressure. Fine wood flour dusted over top before molding gives the lid a smooth paintable surface (bottom right).

Properties

The properties of wood particle moldings, because of the great variation possible through changes in formulation and manufacturing procedure, are not easily described in general terms of strength, weight, and such physical properties. Actually, the properties of this molded wood are almost what would be expected if the process is mentally analyzed.

The first step of the process is to make mincemeat of natural wood; the second step is to homogenize the long and short grain particles; and the third step is to recement the particles together, compressing the wood somewhat in the process. If due allowance is made for the efficiency of the recementing process, as compared to the forces of nature which originally held the wood together, this analysis will result in a fairly clear conception of what the material is. As would be imagined, we have a harder, heavier, more amorphous wood in which the flexural, tensile, and impact strengths, sensitivity to water and humidity, surface hardness, and density are variables of manufacture.

Because the wood portion of the prepared molding blend is much greater than the resin portion, it follows that the finished molded product has many properties that are similar to wood. But the wood has been changed so that desirable properties have been gained and lost. The molded wood product does not have grain or joint weaknesses, but it has lost the beauty of wood grain and the lengthwise-oriented strength of natural wood. The surface of the molded wood is harder and more impervious to liquids than wood, but the uncoated surface of the molded wood is less resistant to wear.

The dimensional stability of molded wood under conditions of changing humidity is better than tangential or radial cross sectional grain wood, but most woods have better stability in the direction of the long grain. Molded wood has a lower rate of absorption in direct contact with water but, given time to penetrate, the water causes greater damage to the physical properties of the molded wood than to natural wood properties.

To be more specific, the flexural strength of an average molded wood particle part is about five times the strength of cross grain yellow birch, and about 1/3 the strength of birch wood along the grain. The screw holding strength is about equal to yellow pine or fir. The weight is about 50 per cent greater than kiln dried maple. The water absorption rate is 10 to 50 per cent that of kiln dried wood.

Relation of Process Variables to Properties

It has been mentioned several times in this paper that the properties of molded wood are a function of manufacturing procedure. Most of the variables which affect the strength and density of molded panel boards affect shape molded articles also, since the two processes are essentially the same except for the shape of the product.

To show the effect of some of the manufacturing variables on the properties of wood particle molding, it will be worthwhile to review some of the scientific studies of these process variables. It has been shown[2] that flexural strength varies as the cube of the specific gravity; water absorption varies inversely with increasing density; and that in the resin content range of 5 to 20 per cent, the density of the product has more effect on these properties than minor changes in resin content. Particle size of the wood granules in the range of 8 to 100 mesh was also found to have less effect on the flexural strength and water absorption than the density variations.

[2] Turner, H. Dale and John K. Kern. 1950. Relation of several formation variables to the properties of Phenolic-resin-bonded wood—waste hardboards. Report No. 1786 U. S. Forest Products Laboratory, Madison, Wis.

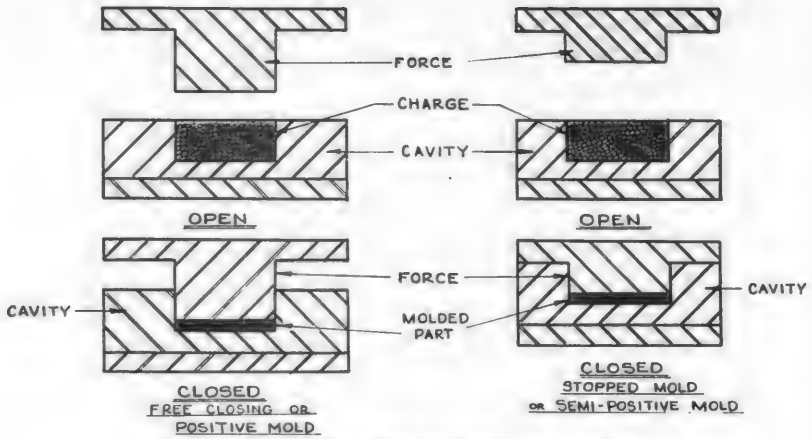

Fig. 3.—Comparison of positive and semi-positive molds.

It has also been found[3] that increased pressure on the molded product increases the density and improves the breaking strength and water absorption properties. Increased resin content increases the density, but in a minor way compared to increased pressure, and also improves the breaking strength and water absorption properties. Softwoods produce articles of higher strength and higher water absorption properties than hardwoods; and softwoods mold to a higher specific gravity for the same molding pressures than hardwoods. Hardwoods produce more water resistant moldings than softwoods.

These studies were made in free closing molds (Fig. 3), that is, molds in which the test moldings were allowed to reach a thickness equilibrium with the molding pressures, which means a higher density with higher molding pressures. In molding wood particle articles to shape, it is the common practice to use stopped molds (Fig. 3) or molds in which the thickness of the piece is predetermined by the mold, which has steel-to-steel contact when the mold is closed.

[3] Williams, Fred H. and Joseph Grano, Jr. 1954. The manufacture of molded articles from resin bonded granulated wood. Jour. of FPRS IV(5):227.

The relation of average density to molding pressure is non-existent in these stopped molds. Provided there is enough pressure to close the mold, the molded part will always be of the same volume, and the weight is purely a function of the weight of material charged to the mold and the volatile content of the charged material. However, the molding pressure does have an effect on the properties of these moldings other than density. Within certain ranges of pressure and resin content, higher molding pressures give greater density and hardness (Fig. 4) to the surfaces of the molded wood particles, higher flexural strength (Fig. 5), and lower water absorption (Fig. 6) to the molded part.

These effects are caused by a relation between heat penetration before the mold closes and the fluxing action of heat on the wood and the resin binder before cure of the resin takes place. The result is a hard, high-density skin condition on the molded product due to the heated, more easily flowing outer material being compressed between the mold surfaces and the cold unfluxed inner portion of the molded part. In many cases, this built-in sandwich construction is advantageous in that lighter weight pieces can be molded for a given application.

Moisture content of the wood particles plays an important part in the properties of molded wood particles. Probably the greatest effect of the moisture content is in its relation to the molding pressure. The relation of wood moisture content to mold closing time is shown in Fig. 7.

The size and shape of the wood particles (in the range of 8 to 100 mesh) has been shown to have little effect on the modulus of rupture or water absorption of molded hardboards.[4] This also holds true in molding to shape, but the size and shape of the particles do have effect on the impact properties. In the range of 40 to 80 mesh, larger particle chips give greater impact strength. This relation probably holds true over a greater range of particle sizes, but our work on impact strength has not included particle sizes out of the range mentioned. Particle shape also has an effect on the impact strength. The more undisturbed long grain wood fiber the particles contain, the higher the impact strength of the molding.

Water repellents may be added to the wood molding material before molding to improve the water absorption properties. Metallic stearates in the very fine powder form are easily dispersed in the fine dry wood flour. Stearates or petroleum waxes may be added to phenolic adhesives by the adhesive manufacturer.

The effect of a small portion of zinc stearate on the water absorption properties may be seen in Fig. 6. These repellents detract from the flexural strength and should be used with caution where the surface of the molded part is to be painted.

These are the most common variables used in wood particle molding. From these the wood particle manufacturer usually tries to develop an article satisfactory for the application. However, there are still other techniques, such as multiple loading, that can be employed if necessary to meet tougher specifications.

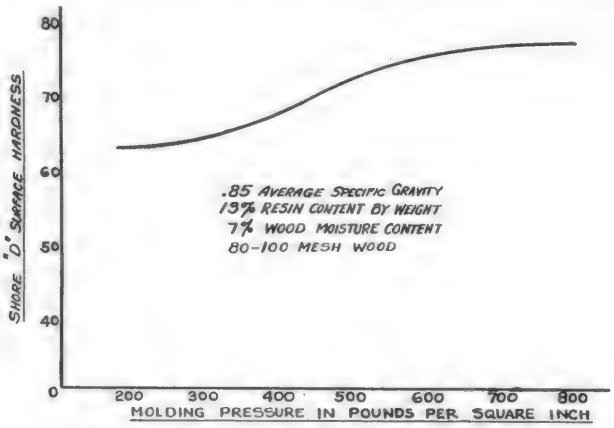

Fig. 4.—Effect of molding pressure on the surface hardness of wood particle moldings.

Finishing Operations

Sanding: Normally, little sanding is done on molded particle parts except to finish the edges formed at the mold parting lines.

Low resin content and low density wood particle moldings sand in much the same manner as wood. Above 20 per cent resin content and above .05 specific gravity, the material is very hard and sands much more slowly. In general the molded wood particles cut faster than wood, but tend to load the

[4] Turner & Kern, op. cit.

grit of sanding belts more than wood. It is usually desirable to use an open-type silicon carbide grit belt, probably of finer grit than would be used for wood. Coarse belts can be used for rough sanding but tend to tear out the wood particles from the molding.

Shaping and Sawing: The material shapes and saws readily. Since it has no grain, it can be cut in any direction. Carbide-tipped shaper and saw blades are a must for any extended operations. Ordinary tool steel cutters have a short life because the material is inherently abrasive and hard. More clearance for chip removal than for wood is usually found advantageous.

Drilling: Most of the machining work done on molded wood particle products is drilling. Mounting holes are required for most applications and holes, especially deep holes, are not conveniently molded in the part.

Drilling shallow holes, up to three or four times the drill diameter, is accomplished with ease. Almost any standard high speed wood or metal boring tool will work satisfactorily.

For deep holes, a fast spiral of 35° helix angle drill is more satisfactory than standard spiral drills. This type drill, commonly called a slate and marble drill, removes the fine powder-like chips more readily than a normal spiral drill. Polished flute drills also facilitate chip removal, and chrome plating not only further helps in chip removal but also works well in preventing wear on the drill diameter. Under the best of conditions, chip removal is a problem on deep holes; it is usually necessary to pull the drill from work to clear the chips every 6 to 10 drill diameters.

Drilling Screw Pilot Holes: When screws are turned into pilot holes in wood particle moldings, a chip may break away from the pilot hole when the screw first enters. This chip may prevent a tight assembly of the part being fastened to the wood particle molding. This problem may be almost completely eliminated by counterboring the pilot hole for a depth of 1/16 to 1/8 inch. The counterbored hole should be slightly larger than the maximum diameter of the screw. Screw pilot holes are usually made a little larger in diameter than for wood, and should be at least as deep as the maximum screw penetration.

Counterboring the screw pilot hole also helps to prevent breakage at the screw hole due to shock on the screwed-on assembly. The counterboring serves to relieve the stress on the edge of the molding and in some cases may triple the shock resistance of the assembly. When counterboring for this purpose, the counterbore should be about twice the diameter of the screw body and at least 1/8 inch deep.

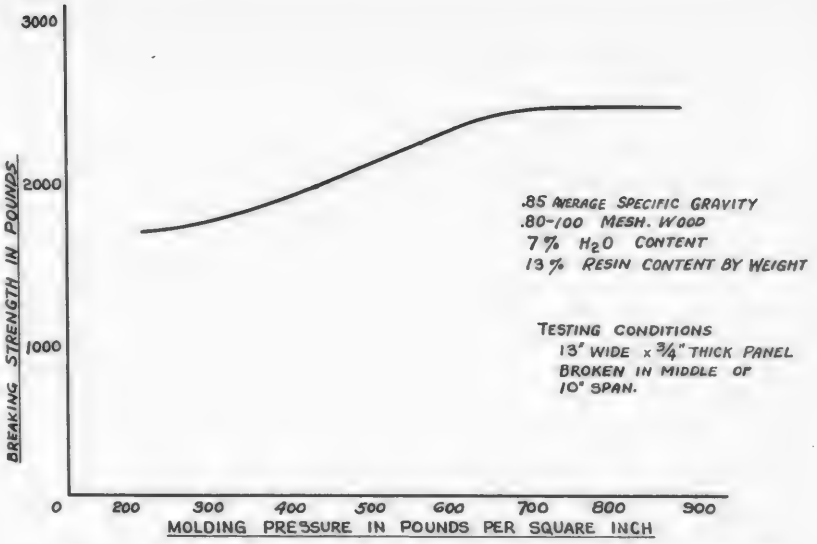

Fig. 5.—Effect of molding pressure on the flexural strength of wood particle moldings.

Surface Finishing: Wood particle moldings will accept any type finish that can be applied to wood. But, unless special precautions are taken, the adhesion between the coating and the molded article may be poor. To improve the adhesion of coatings, the part may be sanded to slightly roughen the surface, or specially compounded sealers or primers may be applied to form an adhesive layer between the wood flour molding and the top coating. The latter method is usually more satisfactory from the standpoint of both economy and smoothness of finish.

Paste fillers may be used if the wood particles used in the molding are large enough to cause small voids which will not be filled or bridged by the surface coating.

One great advantage of wood particle moldings over wood in surface finishing is that properly compounded melamine, urea, or other synthetic high temperature baking enamels may be used without danger of blistering, checking, or joint cracking. Baked enamel operations have been carried out in production at temperatures of 300° F. on molded wood particle

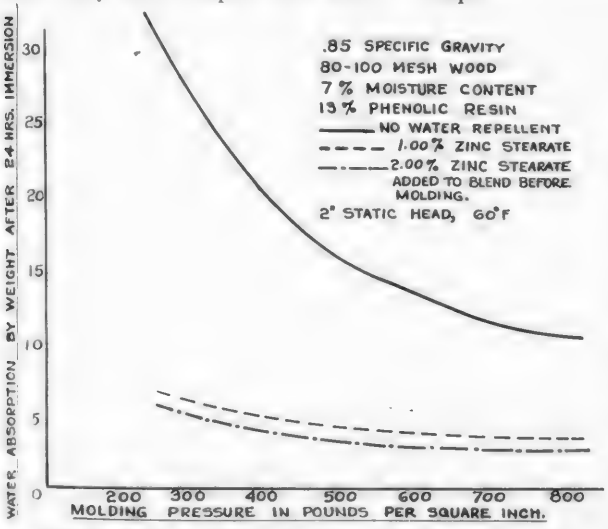

Fig. 6.—Effect of addition of water repellents on the water absorption of wood particle moldings.

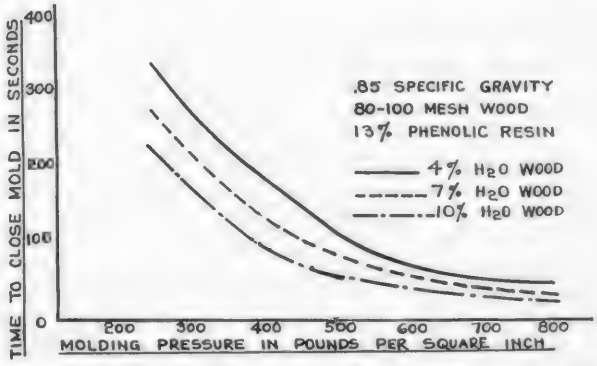

Fig. 7.—Effect of moisture content of wood on the mold closing time.

articles. At this temperature, the enamel is completely set in 15 minutes.

Summary

There is a place for parts molded of wood particles. This is proven by the fact that some 8½ million pounds of resin were used in the United States in 1955, and approximately ten times this amount of ground wood. These figures do not include panel boards. The volume of materials used has been growing steadily since it was first started about 1950.

Toilet seat cores consume the major portion of these materials. This one product consumed about 6 million pounds of resin in 1955. Other products such as croquet balls, shuffleboard discs, women' shoe heels, buttons, toys, brush backs, furniture parts, and salad bowls use about 2½ million pounds of resin per year. Whereas the toilet seat market for molded wood products is nearing saturation, the use of this material in other applications has hardly begun.

Panel boards undoubtedly now represent, and probably will continue to represent, a larger volume outlet for resins and wood than parts molded to finished shapes. But the molded shapes offer a less expensive part where the volume is large enough and offer a great advantage in that custom formulations and custom processing can produce parts better suited for some specific application.

Furthermore, while molded panels use waste raw materials, waste is in turn created when the panels are put into finished products. When the parts are molded to shape, this represents the ultimate in the complete use of the wood. All of the wood ends up in the product and the waste is negligible.

Fundamental Economics of the Particle Board Industry[1]

CARL A. RISHELL[2]

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Basic economic factors of wood particle board manufacturing are discussed, including uses, raw materials, and types of industries now producing these boards. Development of the industry in the United States and Europe is compared and future markets in this country are predicted. Present trends which may influence future growth of the industry are described.

FOR SEVERAL YEARS, people have envisioned the making of boards by combining glue with wood chips and then pressing the mass into a flat or molded sheet. The fundamental idea is simple and workable. Boards and other products can be made by combining chips of any size or shape with any kind of glue, but the simplicity of the process is confined to its fundamentals.

In practice, the majority of all products used in industry have been tediously designed and redesigned to do a specific job. Similarly, wood particle boards which can be sold in the markets must be made of special size and shaped particles and glues that are particularly designed for the end use. Even with the finest raw materials, a modern board cannot be built without careful handling of all the ingredients that go into it.

Wood particle board probably can be best defined as a product made from mechanically processed non-fiberized dry wood particles mixed with a resin adhesive, pressed into shape, and cured with heat under pressure. Among common terms frequently used to designate the product are "chipboard" and "splinter board".

There is popular confusion regarding the differences between "hardboard" and "particle board". As these materials are dissimilar in their form, properties, and uses, it is necessary to clearly differentiate between them.

The basic difference is that, in wood particle board, the particles remain wood as Nature produced it; their composition and fiber arrangement do not change. In dry- or wet-formed fiberboard or hardboard, the fibers in the wood particles have been completely separated, then matted back together and pressed into sheets. The binder in fiberboard is the mechanical interlocking of the fibers, not glue as in particle board.

Wood particle board has many forms. It can be produced in large flat sheets or molded into curved or irregular shapes for special purpose uses. The more versatile boards are those having a smooth surface that can be painted, varnished, or even permit a very thin sheet of highly figured face veneer to be laid directly on the board. Such boards, properly made, have high dimensional stability; when subjected to normal atmospheric conditions, they do not warp or twist. They are relatively strong and will hold screws and nails well. Usually, they are about ¾-inch thick but thinner or thicker boards are practical for certain uses.

Uses for Particle Boards

Wood particle boards serve many uses. When properly constructed with decorative faces — either natural, painted or veneered — they make fine wall covering. Being relatively thick, the material can be used without framing support for show window construction, exhibit booths, and similar purposes. Thin plywood and hardboards, generally used for these items, usually require framing for support.

There are many other current and potential uses for particle boards having special characteristics; among these uses are exterior wall sheathing, roof decking, and subflooring. However, it appears that the principal and immediate large market for the new product is in the construction of furniture and in cores for flush type doors.

Probably the most important factor that the potential particle board manufacturer must resolve, before his operation can be expected to succeed, is determining which of the markets are available to him in sufficiently large volume to maintain a profitable operation, and so located that he can serve them economically.

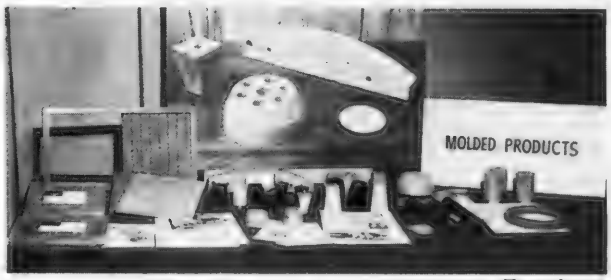
It should be remembered, however, that although the manufacturer may

[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

[2] Mr. Rishell was unable to attend the meeting and paper was presented by R. R. Blumenstein, Assistant Director of Research at Teco.

The Author: C. A. Rishell holds B. S. degree from Penn State College. He was employed in private lumber industry for 12 years, served with Forest Products Division, NRA, before joining NLMA in 1936 as chief of hardwood division. In 1943 he assisted in establishing Teco laboratory, which he headed as director of research until election to present post in 1955. Mr. Rishell served on the first National Executive Board of FPRS.

and probably should, construct his plant to serve present markets, he also should be aware of the newness of the industry and the uses the product may have for future markets. He should make long-range plans and his plant design should be sufficiently flexible to meet future requirements, as well as to take advantage of new opportunities that ensure years of sound operations.



—Teco photo

Fig. 1.—Molded wood products displayed by Chipcraft Corp. at Teco's second international particle board conference in Washington last month.

Raw Materials

For the past 100 years, the dream of the lumber industry has been to find uses for those parts of the log which are not suitable for lumber or lumber products. Pulp chips from slabs, edgings, and low grade logs, provide a partial answer, but the technical requirements for chips for high-grade pulp are such that this solution does not blanket the industry.

Likewise, the gluing together of small dimension for glued laminated products makes it possible for the lumberman to use additional material which used to be wasted, but this also is a partial answer. There are many other uses for wood residues, such as wood flour, charcoal, chemical products, and soil conditioners. These, too, are contributing to raising the utility volume of the log.

Wood particle boards now appear as one of the most important factors in further reducing the wood waste pile. Generally speaking, satisfactory particles can be obtained from any wood species, and they can be green or dry. They can come from slabs, edgings, waste veneers, and from the limbs and slashings in lumbering operations and thinnings in maturing forests.

It would be erroneous to portray this new industry as the complete answer to elimination of wood waste, for only in a diversity of products can the solution be obtained. Nevertheless, wood particle boards will be an important segment in closing the circle.

Therefore, those lumber manufacturers who for various reasons cannot serve the fiber industry with raw chips, or who cannot produce materials for the chemical industry, will find in particle board an additional opportunity to dispose of woods and mill waste. Some will accomplish this increased utilization by operating complete particle board plants in conjunction with their sawmills. Other lumber manufacturers may make only the particles for plants manufacturing the finished boards.

Who Makes Wood Particle Boards and Why

No fixed pattern has been established in the United States regarding the type of industry that will produce the bulk of our wood particle boards of the future. At present, factories are operated by plywood manufacturers, furniture manufacturers, lumber manufacturers, or independent manufacturers that have no other business.

Because the plywood industry is essentially engaged in making panels and veneers for those panels, it is natural that the wood particle boards interest them. The material can be used for cores in veneered panels; for many uses, these panels have the same appearance and, to a limited extent, the same uses as plywood.

The lumber manufacturer has an interest because wood particle boards are approximately the same thickness and have other physical properties of lumber; many of its uses will be the same as lumber. Furthermore, the lumber industry has an untold wealth of raw material from which it can make wood particle boards, without sacrificing the better portions of the log most desirable for lumber production.

The furniture industry has an interest because in wood particle board the potential for a thick, low cost core stock is enticing. Independent manufacturers see in the product an opportunity to construct plants and establish an entirely new business that will not be dependent on any established industry. They see a chance to be the dominant and rewarded pioneers.

There is room in the field for all these various types of potential participants. However, as the industry progresses, small furniture plants and even medium-sized ones probably will find it is more economical to buy the board than to produce it for their own uses.

The smallest economical size particle board plant of the future will produce much more material than the average parent plant can consume. Therefore, if a company makes its own product, it must branch out by selling its excess products to others. As time goes on, a modern particle board plant will require more and more specialized equipment and greater skill to operate it. It will become, in its own right, an independent division of any plant.

A few large furniture companies will have the same advantages in conducting board plant operations as they now have in conducting their own sawmill operations.

Some independent manufacturers will locate their operations close to an adequate supply of raw material, especially in or near centers where particle board is chiefly consumed. If the processes for manufacturing particle board become very complicated, as they may well do, the independent manufacturer will often be able to concentrate and specialize to a greater extent than firms that consider it only as auxiliary to other businesses.

Participation in the particle board industry seems to be a natural development for basic forest products industries that have large supplies of suitable and as yet unused raw materials available for board manufacture. If this material is waste or of low value, these companies will have much advantage over others. For this reason, many sawmill companies should consider this product as something that they can produce economically.

The lumber industry has another important interest — particle boards may compete for current lumber markets even more than for plywood or hardboard markets. The retention of these lumber markets by making a new product is a sensible thing to do.

Development in the U. S.

The serious development of wood particle board in the United States began about seven years ago. It was probably made possible at that particular time because urea formaldehyde glues were discovered to be well suited for particle binders. They were the first successful adhesives for this use because of suitable properties and economical cost. Prior to the second World War, some successful attempts were made to produce particle boards but satisfactory glues were not then available in sufficient quantities or at least were not generally known. Therefore, practical development did

not come until war's needs were satisfied and raw materials became available for other uses.

Since the beginning of particle board development in the United States, the marketing problems have not been well understood. Most of the pioneers had in mind the production of all-purpose boards. The board was known to be suitable for door and furniture core stock, but it was more often thought of as a material that could be used for wall paneling, subflooring, sheathing, and many other purposes. Until recently, the industry did not concentrate on markets most easy to invade. It diluted its efforts in an attempt to be "all things to all men."

Development in Europe

In spite of a common heritage of products and processes, development of the particle board industry in Europe has been along different lines than in the United States. In the beginning, there were of course some points of similarity. The board could not be developed in Europe any more than in the U.S. until adequate glues became available after World War II.

In Germany, where the particle board industry has reached the highest state of advancement, ownership has been largely controlled by the furniture industry but there are some exceptions. After the war, it was necessary to rebuild a destroyed country in the quickest possible way and with any available materials. Home furnishings were almost as urgently needed as the houses themselves, but the sources of supply for furniture core stock were practically nonexistent.

Furthermore, the timber resources for lumber production in Germany were so badly damaged that the local source of supply, always inadequate, was even smaller than usual. The only other source of furniture and door stock was through importation, but the country lacked money, particularly dollars. However, labor was cheap and there was sufficient small timber for the job, if in some way it could be converted into a useful form. Gluing small chips into usable panels seemed to be a logical solution, for in this way even the smallest twigs could be used.

The German furniture industry, on its own initiative, went to work on particle boards. Both large and small furniture plants experimented and found that a usable material could be made in tiny, crudely equipped plants. They usually were built adjacent to the furniture factories. During the first stage of development, the amount of equipment required was extremely meager. Because of the great demand for materials, the German consumer was not critical but would accept almost any useful product.

The small trees in the forests, which impeded the growth of the larger trees and usually were used for firewood, were taken to the furniture plant, ground into particles, mixed with glue, and pressed into a serviceable panel. Any reasonable amount of labor could be put into the job so long as the usable product came out the other end of the plant. The average European furniture plant being small, the first desperate need for panel stock did not last too long. As the industry became confident of its ability to supply its basic needs, it undertook an orderly improvement of the product.

The Germans' success in this initial development was such that the technical brains of the country were put to work to improve the board and reduce the cost of manufacture. A laboratory, principally financed by the industry, was built. In this laboratory, various glues were examined, but more important, the form of the wood particle was invented which has now become known in Germany as a flake. Development of this flake, more than any other factor, has enabled the Germans to produce their highest type of board.

A most significant observation in this development is that the Germans, each year for the past seven years, have doubled their production of wood particle board, with no increase in total man hours for the expanded production. That the cost has come down is an accomplishment, but the real magnitude and excellence of the development is evidenced in a comparison of the boards of 1948 and 1955.

To obtain this excellence in products, the Germans have designed special flaking equipment. They have built special hot plate presses, new distributing equipment, and many refinements. Perhaps more than anything else, they have developed the technique of specializing in a special field.

Perhaps it was accidental that the Germans specialized in core stock but, regardless of the reason, it was fortunate. In other fields, there were many alternate materials that could be used —concrete, bricks, stones, steel and aluminum—but for core stock, there was no competition. Furniture core stock is probably one of the most exacting materials made from wood. Although sub-flooring, sheathing, and other things, in general, require somewhat similar properties, they need not be so highly refined for these purposes. Thus, the German industry, by accident of design was forced into the most logical market development.

The German refinement of particle board is adequate for that country and many of the things which have been done there can be used in the U.S. However, the differences in economy are such that the average German plant could not be uprooted, brought to this country, and put into successful operation. Each foreign country and each area of the United States must have plants specialized for the type of economy most favorable to it. For example, in Germany the standard rate of pay is one mark per hour. In the U. S., it is five times this amount. Wherever such difference exists, it would be rank folly to transplant without grafting.

Future Developments in the U. S.

There is a marked trend in the United States toward developing boards having finer properties than those which were acceptable a few years ago. The changes taking place are due to two factors. First, there is a natural improvement of any product when technical brains, such as we have in the U.S., go to work on it. Eventually, this natural influence alone would be responsible for a product best suited for our own needs and of a quality second to none.

The second factor is that, to speed this eventual outcome, many U.S. firms are profiting from the German development. They have brought back to this country the foreign methods for progress, which will be combined with our own ideas. This will result in a truly American product, made in traditional U.S.-designed plants.

Many firms have imported German know-how and others are taking advantage of knowledge which has been brought back by teams of technical people, sent to Europe to obtain information for them. The engineering services in our nation are quite adequate and competent to utilize this information, and will do so when their customers require the equipment, plants and products of the highest type.

Our own wood-using industries should continue their European investigations so that the usable information which the Germans have can be imported to this country. Likewise, we have facilities and know-how in this country that can be helpful to the Germans. Cooperation in such technical matters is a sensible thing that can do much for us and them.

One of the principal things needed in the U.S. is a complete understanding of the market potentials for particle board. Only when industry thoroughly understands these potentials will it be competent and willing to

develop products of the quality required for our particular needs.

Second, the industry must have a centralized organization[3] or clearing house so that mutual problems can be discussed and thoroughly understood by the majority of organizations making the product. This is important to every manufacturer. Those who do not keep abreast of developments will be forced out of business. While this is going on, however, these failures will load the market with inferior products. Such unfortunate occurrences cannot be entirely avoided, but they may be minimized.

The industry needs to establish minimum performance standards on which to build. It needs grading rules and it needs technical equipment and technical organizations specialized in the field.

Future Markets

In order to predict future markets for particle board products it is necessary to know their properties, methods of manufacturing, and the economics in production.

The most important manufacturing principle in particle board, as differentiated from fiberboard, is that particle boards are usually made from dry wood residues, whereas fiberboards are produced from wet fibers dispersed in water. Particle boards require a relatively large amount of binder to hold them together, but the fiber-type board requires little and in some instances none. It is therefore the cost of glue in the one instance and the expense of drying in the second instance which creates an economic separation of the two products.

At the present time the drying of fiber-type boards of over 3/8 inch thick, made by the wet process, is probably too expensive. Therefore, fiber-type boards are limited to relatively thin material.

Wood particle boards, on the other hand, require from 7 to 10 per cent adhesives. These glues normally sell for 15 to 20 cents a pound. The amount of resin in a particle board may roughly be calculated at about 50 per cent of its cost. Because of the glue costs and physical properties, particle boards are seldom made less than 1/2 inch thick and they are at their best at about 3/4 inch thick. This is the basic economic principle of the products and is a large factor in determining where wood particle boards and fiber-type hardboards meet for competition.

This situation will, of course, waver back and forth as glues are reduced or increased in cost, and as new methods for drying fiberboards, or for making a dry-type fiberboard, are developed. Each industry will strive to secure advantages, but outside of the cost of drying and of adhesives, the other costs such as labor, wood, and raw materials are less important.

As particle board, in the foreseeable future, will be rather thick products because of glue costs, competition will probably be with lumber rather than hardboard or conventional plywood. In competing with lumber, particle board can readily absorb the glue cost, so competition will emphasize differences in physical properties. In some instances, these physical properties will favor solid lumber and in others it will favor particle board.

Here, as in Germany, the natural first market for particle board is in the core stock field. This stronghold of solid lumber has been invaded and the invasion will continue until almost completely dominated. This therefore is the first natural outlet for the product and with success in this field the industry will have time and money to improve the properties of the product for other uses and to reduce costs.

By these means, the particle board industry will gradually expand as it will produce products that are admirably suited for many markets. It is never expected to be a general purpose board, such as lumber, plywood, or even hardboard. For each market it will be highly specialized and therein lies the road for successful development for this infant industry.

Another important factor that will influence the future market potentials is the capability of the industry to install modern plant equipment. Seven years ago a particle board plant could be constructed in the U. S. for $100,000 to $125,000. This period is now over. The equipment, excluding buildings, for a particle board plant to produce, on an economic basis, the most modern product will cost not less than $400,000 to $450,000.

The time is past when large amounts of hand labor can be afforded, glue wasted, or particles formed in a haphazard way. On the other hand, the firm that has the courage and conviction to go ahead immediately with a properly located plant, well engineered and properly constructed, can produce a product that will have little competition on the American market. This, however, is a fleeting moment that will be quickly dissipated.

Ten Years in the Future

The struggle for markets and perfection of processes is just beginning. Improved American and Americanized German plants are under construction and, even prior to this, Swiss-designed plants were in the field commanding the highest prices paid for particle boards. Organizations that are unable or refuse to accept the advancement which is plainly visible to those who will look will be unable to sell products having inferior properties. Like every other industry, the cost to the consumer of these better quality products will be no greater than is now being paid for inefficiently made, lesser quality boards. It is true that the cost of an ultra modern plant installation may be several times as high as formerly, but this will pay off in increased production and in more favorable market opportunities.

The trend toward higher plant equipment costs is continuing. The end is not in sight. However, the particle board industry is and probably always will be a type of manufacturing that can be indulged in by relatively small firms as well as larger ones. This will hold true unless the fundamental principles are radically changed, which does not seem probable.

Improved flakers and chippers will cost somewhat more, as will better prepresses, final pressing equipment, and spreading devices. But all of these are rather simple devices which costwise should never get completely out of hand.

As the industry develops, new adhesives will be produced. These will be special products having better properties than anything we know today. For some uses it is logical to expect fully waterproof adhesives at reasonable cost. Glues will be developed requiring smaller proportions in the mix.

New American flaking or chipping machines, far better for our needs than anything the Germans can offer, will be developed. These will permit the use of dry as well as green wood, and they probably will take wood in all forms and shapes from the smallest to the largest sizes. As all these and many other improvements develop, the boards will be given different and better properties and, with reductions in cost which are on the way, the market potentials are so great that accurate long range prediction is impossible.

[3] Since this paper was presented, a Particle Board Association has been formed with the objective of establishing standards, nomenclature, and test procedures for the industry. The organization meeting in Oct. 1956 was the result of work by a committee appointed by the National Lumber Manufacturers Association.

The Effect of Dryer Temperatures Upon the Gluing Properties of Douglas-fir Veneer[1]

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Reported difficulties in procuring uniformly satisfactory adhesion during the manufacture of Exterior Grade Douglas-fir plywood prompted a study of the role of dryer schedules in glue bond quality. Reduced bond quality, as recorded by the industry standard based on wood failure, was shown to result from excessively severe drying schedules. This recorded reduction in bond quality was found to be attributable to reduced strength of the wood rather than to reduced adhesion.

DURING THE PAST 20 YEARS, Douglas-fir veneer-dryer temperatures have been increased from slightly above 212° F. to temperatures in excess of 300° F. Temperatures as high as 394° F.[2] have been recorded by the author in commercial veneer dryers. The use of increasingly higher drying temperatures has been believed to cause certain plywood bonding difficulties. The purpose of this paper is to report the findings of research which was conducted to investigate the effects of dryer temperatures upon the gluing properties of Douglas-fir veneers.

For the purpose of this study, only phenolic-resin adhesives were used. These were chosen because most of the plywood manufactured in British Columbia is bonded with this adhesive. Veneers prepared from both Interior and Coast[3] Douglas-fir trees were included in the study because of the reported differences in gluing characteristics of trees from these different regions.

The data in this report were derived from three closely related projects. The first, which is reported in Part I, was undertaken to investigate the causes of gluing difficulties which had been experienced by plywood manufacturers. Veneers which were being dried at excessively high temperatures produced faulty bonds, and these poor bonds were thought to be due to a breakdown of adhesion. It was from this point of view that this research was commenced.

By the time the research outlined in Part I was finished, it was realized that any reduction in adhesion was confounded with reduced strength of the wood and the research presented in Part II was undertaken for the purpose of separating the effects of these variables.

Finally, the research reported in Part III was conducted to further investigate questions which still remained unanswered after Parts I and II had been completed.

Part 1

For this study of the effect of dryer temperatures upon the gluing properties of Douglas-fir veneers, the following factors were included in the statistical design:

(a) Dryer temperature: three temperatures—330° F., 444° F., and 543° F.

(b) Time in the dryer: four periods oven-dry, oven-dry plus 10 minutes, oven-dry plus 20 minutes, and oven-dry plus 30 minutes.

(c) Locality: two localities—Interior and Coast.

(d) Trees: 26 trees from each locality were included in the sample.

Specimens prepared from each tree and locality were subjected to each of the 12 possible combinations of temperature and time. The veneers from Interior-grown trees were 0.200 inch thick while those from the Coast-grown trees were 0.232 inch thick.

From the veneer of each log, 24 glue blanks each 3.6 inches square were sawn. Thus eight plies were available for drying at each of the three drying temperatures. The veneers were dried in the following manner.

With the hot-press platens at the desired temperature, the eight glue blanks of each press load were placed side by side in a hot press, the platens were closed, and pressure of 10 psi was applied for 10 seconds. Pressure was then removed for 5 seconds so that steam could escape. This cycle was repeated until the specimens were removed from the press. In order to determine when each press-load of specimens reached oven-dry conditions, one specimen was removed and weighed at intervals. When two consecutive weighings were identical, the press-load of specimens was considered oven-dry and the two oven-dry specimens were removed from the press. The cycle was continued for another 30 minutes and two glue blanks removed after each 10-minute period.

Preliminary study had indicated that this method of drying produced the defect which it was desired to study. The method also provided a range of drying temperatures and times which could not be obtained in factory dryers but which were essential to this study.

The dried glue blanks were allowed to reach equilibrium moisture content in an atmosphere of 70° F. and 32 per cent relative humidity before gluing. All specimens were glued in the same manner with a hot-press phenolic-resin adhesive. The glue was mixed, applied, and pressed according to manufacturer's instructions. "Tight" faces of veneers were glued together with their grain parallel i.e., they were laminated and not cross-banded.

Misgivings have been expressed that laminated specimens could be expected to yield information regarding the bond quality of cross-banded veneers. In the author's opinion, other factors being equal, the adhesion should be the same for cross-banded as for laminated veneers. It is not intended to imply that breaking loads will be identical, only that the "stick" of the glue to the wood will be unchanged by the direction in which the wood cells of the opposing blocks are oriented with respect to each other. It was anticipated that similar patterns of results would be obtained with laminated as with cross-banded material. This hypothesis was substantiated by a comparison of the results of parts 1 and 2.

From each tree one 3.6-inch-square glue lay-up was prepared for each of the 12 possible combinations of drying temperature and drying time. The

[1] Presented at meeting of FPRS Pacific Northwest Section, Feb. 6–7, 1955, in Longview, Wash.

[2] Since the completion of this work, a tour of inspection of direct-fired dryers has been made and temperatures over 500° F. noted.

[3] In this report the word "Interior" is used as a proper name, replacing the phrase "interior of British Columbia", and "Coast" in lieu of "the coastal region of British Columbia."

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glued blanks were allowed to reach equilibrium moisture content in an atmosphere of 70° F. and 32 per cent relative humdity before they were cut into test specimens.

Three methods of testing the bond quality were used: The Tension Shear Test[4], the Tension Normal to the Glue Line Plywood Test (6),[5] and the Glueline–Cleavage Test (4). The results of three methods of test are available for this study because two independent projects were conducted on the same material: first, a study of the relative accuracies of the three test methods, and second, the study herein reported of the effect of a dryer temperature and time on the gluing properties of Douglas-fir.

The Plywood Shear Test, while designed to measure the shear strength of the bond, does not always do so. It can be demonstrated that failure with this test frequently, if not usually, occurs in tension perpendicular to the glue line (and grain). Both the Tension Normal to the Glue Line Plywood Test and the Glueline-Cleavage Test were designed to measure the bond strength perpendicular to the glue line (and grain). Each method of test yielded two independent estimates of the bond quality, one from the breaking load and another from the percentage of wood failure. Six independent estimates of bond qaulity were therefore available.

From each 3.6-inch-square glue assembly was sawn one Tension Shear specimen with 1″ x 1″ test cross-section, one Tension Normal specimen with 1″ x 1″ test cross-section, and five 1″ x 1″ Glueline-Cleavage specimens.

The Tension Shear and Tension Normal specimens were prepared in the customary manner and broken in a 30,000-pound Universal testing machine with special rider which reduced the top of the range to 3,000 pounds. The Glueline–Cleavage specimens were tested in a machine developed at the Vancouver Laboratory (4) with 90° knife angle. The machine was greased with a light-bodied cup grease before each test.

Results

The test results for Part 1 are summarized in Table 1. The Glueline-Cleavage figures (1A and 1D) are the means of 130 tests, the remainder are the results of 26 tests each.

Because appearance assessments (per cent wood failure) were the basis of the conclusion that bond quality was affected by dryer temperature, it was logical to analyze the wood failure results first. These results, summarized in Table 1 (1D, 1E, 1F), are presented graphically in Figs. 1a, 1b, and 1c. Figs. 1a to 1c inclusive are photographs of three-dimensional graphs. Dryer (hot press) temperature is plotted along the front of the model:

[4] The Tension Shear specimen is similar to the Plywood Shear specimen (1) but is of twenty construction.

[5] Numbers in parentheses refer to literature cited.

Table 1.—SUMMARY OF PART I DATA

GLUELINE CLEAVAGE TEST

	DRYER TEMPERATURE								
	330° F.		444° F.		543° F.				
	Region		Region		Region				
	Coast	Interior	Coast	Interior	Coast	Interior	TOTALS (Coast)	TOTALS (Interior)	TOTALS
MEAN BREAKING LOADS (POUNDS)									
Oven-dry	270	332	245	250	182	178	697	760	1457
O. D. + 10 mins.	294	309	197	194	147	164	638	667	1305
O. D. + 20 mins.	270	313	194	185	147	160	611	658	1269
O. D. + 30 mins.	272	291	192	178	123	140	587	609	1196
TOTALS (Coast)	1106		828		599		2533		
TOTALS (Interior)		1245		807		642		2694	
TOTALS	2351		1635		1241				5227
			Table 1-A						
MEAN WOOD FAILURES (PER CENT)									
Oven-dry	100	100	89	75	95	64	284	239	523
O. D. + 10 mins.	97	95	74	56	95	95	266	246	512
O. D. + 20 mins.	95	86	68	52	93	96	256	234	490
O. D. + 30 mins.	94	82	66	53	87	92	247	227	474
TOTALS (Coast)	386		297		370		1053		
TOTALS (Interior)		363		236		347		946	
TOTALS	749		533		717				1999
			Table 1-D						

TENSION SHEAR TEST

	DRYER TEMPERATURE								
	330° F.		444° F.		543° F.				
	Region		Region		Region				
	Coast	Interior	Coast	Interior	Coast	Interior	TOTALS (Coast)	TOTALS (Interior)	TOTALS
MEAN BREAKING LOADS (POUNDS)									
Oven-dry	450	406	351	300	200	179	1001	885	1886
O. D. + 10 mins.	422	412	335	253	178	161	935	826	1761
O. D. + 20 mins.	442	383	286	259	183	144	911	786	1697
O. D. + 30 mins.	406	378	287	241	162	123	855	742	1597
TOTALS (Coast)	1720		1259		723		3702		
TOTALS (Interior)		1579		1053		607		3239	
TOTALS	3299		2312		1330				6941
			Table 1-B						
MEAN WOOD FAILURES (PER CENT)									
Oven-dry	93	99	94	95	100	94	287	288	575
O. D. + 10 mins.	96	98	91	78	99	99	286	275	561
O. D. + 20 mins.	98	97	90	81	99	100	287	278	565
O. D. + 30 mins.	98	94	90	62	99	99	287	255	542
TOTALS (Coast)	385		365		397		1147		
TOTALS (Interior)		388		316		392		1096	
TOTALS	773		681		789				2243
			Table 1-E						

TENSION NORMAL TEST

	DRYER TEMPERATURE								
	330° F.		444° F.		543° F.				
	Region		Region		Region				
	Coast	Interior	Coast	Interior	Coast	Interior	TOTALS (Coast)	TOTALS (Interior)	TOTALS
MEAN BREAKING LOADS (POUNDS)									
Oven-Dry	118	131	99	103	61	66	278	300	578
O. D. + 10 mins.	117	142	78	94	53	52	248	288	536
O. D. + 20 mins.	115	140	77	93	49	59	241	292	533
O. D. + 30 mins.	115	146	70	86	42	58	227	285	512
TOTALS (Coast)	465		324		205		994		
TOTALS (Interior)		559		376		230		1165	
TOTALS	1024		700		435				2159
			Table 1-C						
MEAN WOOD FAILURES (PER CENT)									
Oven-dry	100	100	100	98	100	93	300	291	591
O. D. + 10 mins.	100	98	100	86	97	95	297	279	576
O. D. + 20 mins.	99	99	91	85	98	98	288	282	570
O. D. + 30 mins.	98	96	97	77	99	96	294	269	563
TOTALS (Coast)	397		388		394		1179		
TOTALS (Interior)		393		346		382		1121	
TOTALS	790		734		776				2300
			Table 1-F						

Fig. 1a.—Glueline-Cleavage Wood Failures Fig. 1b.—Tension-Shear Wood Failures Fig. 1c.—Tension-Normal Wood Failures

Figs. 1a to 1c.—Relationship between drying temperature, time in the dryer, and per cent wood failure for three methods of test.

330° F., 444° F., and 543° F. Along the side is plotted drying time, from oven-dry at the back to oven-dry plus 30 minutes at the front. The vertical scale represents the wood failure in per cent. The white top surface of Fig. 1a represents the wood failure as measured from the Glueline–Cleavage specimens. Fig. 1b presents the wood failure results as determined from the Tension-Shear specimens, and Fig. 1c the same information from the Tension-Normal Specimens. All three figures indicate the same pattern of results, but they differ in degree.

The highest wood failure, and by inference the highest bond quality, occurs at the point where both temperature and drying time are at a minimum. As the temperature increases from 330° F. to 444° F. the wood failure drops from between 90 and 100 per cent to as low as 60 per cent. With further increase in temperature to 543° F., this trend is reversed and the wood failure increases to between 90 and 100 per cent. This drop in wood failure between 330° F. and 444° F. was anticipated, but the increase at 543° F. was quite unexpected. When the effect of time in the dryer upon wood failure is noted, a tendency is observed for the wood failure to decrease with increased drying time.

Attention was next directed to the breaking loads which are summarized in Table 1 (1A, 1B, 1C) and in Figs. 2a, 2b, and 2c. In these figures the vertical scale represents the breaking load in pounds. The top (white) surface of Fig. 2a represents the breaking loads of the Tension-Normal specimens. For specimens dried to zero moisture content (O.D), the breaking loads are 128 pounds for those dried at 330° F., 100 pounds for those dried at 444° F., and 64 pounds for those dried at 543° F. When the wood is dried for an additional half hour (O.D. plus 30), the breaking loads are 128, 78, and 48 pounds, respectively, as the temperature increases.

Fig. 2b presents the breaking loads of the Glueline-Cleavage specimens and it can be seen that they follow the same pattern as the Tension-Normal results. Fig. 1c represents the breaking loads as determined by the Tension-Shear method. Again there is the same pattern as the other two maximum breaking load, and by inference maximum bond quality, with minimum temperature and time, and minimum breaking load with maximum temperature and time.

Based upon breaking loads, all three methods of test indicated a reduction in bond quality with increased drying temperature, and with increased time in the dryer. Wood failure results indicated the same trends for an increase in temperature from 330° F. to 444° F. but reversed this trend with further increase in temperature. Because the trend indicated by the breaking loads was more logical than that indicated by the wood failures, and because of previous dissatisfaction with wood failure as an indicator of bond quality (5), it was decided to relegate wood failure to a minor role in the analysis of the test results.

Wood failure was estimated by means of the industry standard.

A statistical analysis of the data was made. Because all test methods indicated the same trend, any one of the three could have been used for the analysis. The Glueline-Cleavage data were chosen because of the larger number of specimens per tree which were available.

The analysis of variance of the Glueline-Cleavage breaking loads indicated highly significant differences ($p = 0.01$ level) due to drying temperatures, significant differences ($p = 0.05$ level) due to time in the dryer, and no significant difference due to locality of growth.

Examination of the means in Table 1 (1A, 1B, and 1C) reveals the two major trends which have been confirmed by the analysis of variance of the figures entering into Table 1A: the higher the drying temperature, the lower the breaking load; the longer the drying time, the lower the breaking load. Trees from both localities reacted similarly to one another.

Up to this point the thinking was that the reduction in breaking load, or wood failure, measured a reduction in bond quality. However, in the Tension-Normal specimens most of the failures occurred at a considerable distance from the glue line, so that the bond could have had nothing to do with the reduction in breaking load. The fact that the Tension-Normal results followed the same pattern as the other two methods suggested that a considerable portion of the reduced breaking loads was due to the lower strength of the wood rather than to any breakdown in adhesion.

It also raised some doubt that any glue failures had been developed. A count of the number of specimens with 50 per cent or less wood failure showed no Coast and 12 Interior when dried at 330° F., and 22 Coast and 48 Interior when dried at 444° F. This information appeared to substantiate the original hypotheses that higher temperatures yielded a higher percentage of glue failures and that the Interior-grown trees tested produced a higher percentage of glue failures than did Coast-grown trees tested.

At this stage of the investigation it was considered that:

(a) the strength of the wood was reduced by drying veneers at excessively high temperatures and for excessively long times:

(b) bond strength was reduced by drying veneers at excessively high temperatures and for excessively long times:

(c) veneers dried at 444° F. developed a greater percentage of glue failures than did those dried at 330° F.:

(d) veneers cut from trees which grew in the Interior of British Columbia developed a greater percentage of glue failures when dried at high temperatures than did those from trees which grew in the coastal area:

(e) veneers from Interior-grown and Coast-grown Douglas fir trees followed the above pattern:

(f) wood failure results did not give a very reliable estimate of bond quality.

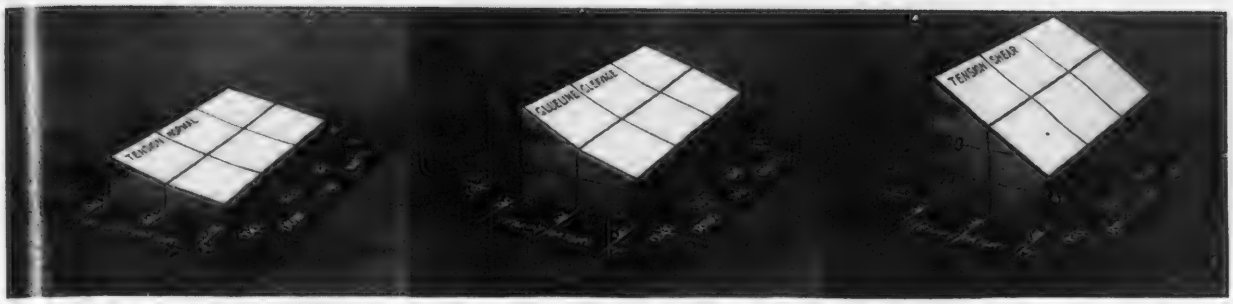

Fig. 2a.—Tension-Normal Breaking Loads Fig. 2b.—Glueline-Cleavage Breaking Loads Fig. 2c.—Tension-Shear Breaking Loads

Figs. 2a to 2c.—Relationship between drying temperature, time in the dryer, and breaking load in pounds for three methods of test.

Part 2

In an attempt to separate the reduction in strength of the bond from that of the wood, another investigation was undertaken. It was decided to use the Glueline-Cleavage method of testing for strength. Solid wood and glued (cross-banded) specimens were prepared from wood as closely matched as possible. It was reasoned that the differences between the breaking loads for solid-wood and glued-wood specimens (which had been matched for material and subjected to identical treatment) would be the reduction in strength due to bond interference. It was further reasoned that these differences could be separated by analysis of co-variance.

Apart from the differences in strength between solid and glued wood, the factors to be studied included: four dryer temperatures—225, 300, 375, and 450° F. four drying periods—oven-dry, oven-dry plus 20 minutes, oven-dry plus 40 minutes, and oven-dry plus 60 minutes two localities—Interior and Coast and seven trees from each locality. Specimens from each tree and locality were subjected to each of the sixteen possible combinations of temparture and time.

Glued Specimens: Green edge-grain boards were sawn at an angle of 10° to the tracheids of the wood for preparation of EGx10° (glued) specimens (4). These boards were planed to 0.210 inch thickness and sawn into pieces 0.210″ x 4″ x 4″. These pieces were kept in the green condition until ready for drying.

The veneers were dried in a forced-circulation oven. The oven-dry point was determined by suspending the veneers from a balance and keeping a record of weight and time as drying progressed.

The 4-inch square glue blanks were glued together in pairs, using a hot-press phenolic-resin adhesive according to the manufacturer's instructions, every precaution being taken to insure that gluing conditions were as nearly identical as possible for all specimens. The matching veneers were glued together with the grain of the two veneers at right angles to each other (i.e., cross-banded).

After they had cooled to room temperature, the glued assemblies were placed in an atmosphere of 70° F. and 32 per cent relative humidity. After these assemblies had reached equilibrium moisture content they were sawn into 1-inch square Glueline-Cleavage test specimens and returned to the humidity chamber until required for testing. Five of the six specimens were tested as soon after removal from the humidity chamber as possible—in a matter of a minute or less.

For each specimen, the following information was obtained:

(a) the breaking load in pounds:
(b) the wood failure in per cent;
(c) the moisture content at test.

The specific gravity of the sixth specimen from each glue blank was measured, the specimen used for this purpose being chosen so that it would be representative of all of the six specimens from that blank.

Solid Wood Specimens: From the same pieces of wood used for the preparation of glued-wood specimens, a number of 0.420 inch thick edge-grain boards were sawn and planed. Specimens were sawn from these boards 1.00″ x 1.00″ x 0.420″ so that the tracheids were parallel to the faces and edges of the specimens. For each of the sixteen drying schedules, five specimens were chosen from each tree and these were dried to their appropriate schedules following the same drying technique as was used for the glued specimens. Conditioning and testing procedure was the same as for the glued specimens and the same information was recorded.

Test Results

Analyses of variance of the breaking loads of both the glued specimens and the solid wood specimens showed the same trends as did the data of Part 1. Higher drying temperatures and longer drying times yielded lower breaking loads, and differences between Interior-grown and Coast-grown trees were not significant.

Difficulties were encountered in segregating the reduction in strength of the wood from the reduction in adhesion. When this project was initiated it was naively considered that subtracting the breaking load of a glued specimen from the breaking load of the matching solid wood specimen would give an estimate of the loss of adhesion. From other work not herein recorded, it was discovered that, if a piece of wood is broken in the cleavage machine, the pieces glued together and then broken a second time, the second breaking load will be approximately 10 per cent greater than the first. It was noted that breaking loads of cross-banded specimens are lower than those of laminated specimens. From other available data the conversion factor necessary to compare cross-banded

Table 2.—SUMMARY OF MEAN BREAKING LOADS OF GLUELINE–CLEAVAGE SPECIMENS

(Solid Wood and Glued Wood)

Each figure is the mean of 35 tests

	SOLID WOOD							
	Coast				Interior			
	Drying Temperatures				Drying Temperatures			
Drying Time	225° F.	300° F.	375° F.	450° F.	225° F.	300° F.	375° F.	450° F.
Oven-dry	342.3	316.0	286.0	274.7	337.4	312.7	308.6	279.3
O.D.+20	337.4	318.4	268.0	211.1	339.8	316.8	290.7	225.4
O.D.+40	327.7	300.3	244.1	192.0	333.3	310.2	280.0	212.4
O.D.+60	333.7	295.7	248.0	192.3	333.8	315.1	281.4	206.4
	GLUED WOOD							
	Corrected for direct comparison with Solid Wood							
Oven-dry	312.8	305.7	279.4	271.1	323.4	333.1	317.7	278.6
O.D.+20	309.4	293.1	265.1	215.1	334.2	323.7	292.3	222.3
O.D.+40	320.0	297.7	241.7	213.1	342.3	333.1	280.8	226.3
O.D.+60	300.6	286.6	237.7	206.6	330.8	314.6	272.8	223.4

Mean Breaking Loads (pounds)

with laminated specimens was calculated to be 1.42[6].

The mean breaking loads for solid wood specimens are set down in Table 2, also the mean breaking loads of the glued specimens corrected by means of these factors for direct comparison with the breaking load of their matching solid wood specimens. Each figure is the mean of 35 tests—5 specimens from each of 7 trees. A "t" test of the paired data showed no significant difference between the corresponding mean breaking loads of glued and solid wood specimens. The conclusion drawn from Part 2 is, therefore, that all of the reductions in breaking loads were associated with the reduced strength of the wood and none was traceable to inferior adhesion.

The evidence provided by Part 2 regarding the possible source of reduced breaking loads of specimens dried at high temperature conflicts in certain details with that provided by Part 1. In the beginning, the defect being studied was presented as one of faulty adhesion. The exploratory investigation (Part 1) appeared to confirm the hypothesis of faulty adhesion but introduced another hypothesis, that at least some of the reduction in strength noted was attributable to the altered strength of the wood and not to the adhesion. Further experimentation (part 2) with a different method of drying veneers produced no bond which the author was prepared to class as faulty adhesion, but yielded the information that the reductions in strength were attributable solely to the wood.

At this point in the investigation the problems were reviewed in detail with plywood and glue manufacturers' technical representatives. They were convinced that the problem was one of faculty adhesion and presented certain evidence which supported their contention. It was decided, therefore, to conduct further work at a plywood factory.

Part 3

Factory Investigations: In order to resolve the question "Were the suspect glue bonds due to reduction in strength of the wood or to a breakdown of adhesion?", further experimentation was undertaken at a plywood plant. Douglas-fir heartwood veneers were run through the dryer at different schedules.

Veneers 0.171 inch thick from each of 15 Douglas-fir trees were dried to the following drying schedules:–

Schedule A1—dried in the hot-press at 350° F. to oven-dry.

Schedule A2—dried in the hot-press at 350° F. to oven-dry plus 30 minutes.

Schedule A3—dried in a forced-circulation oven at 350° F. to oven-dry.

Schedule A4—dried in a forced-circulation oven at 225° F. to oven-dry.

Schedule B1—dried in a roller-type veneer-dryer at a maximum temperature of 355° F. for 19 minutes (Douglas-fir heartwood schedule).

Schedule B2—twice through the Douglas-fir heartwood schedule.

Schedule C1—dried in the same dryer as was used for Schedule B1, but with a charge of cottonwood (*Populus trichocarpa*), maximum temperature 355° F. and times as follows: trees 1 to 5 inclusive for 27 minutes; trees 6 to 10 inclusive for 20 minutes and trees 11 to 15 inclusive for 21 minutes.

Schedule C2—twice through the cottonwood schedule (C1) for the following times: trees 1 to 5 inclusive for 54 minutes; trees 6 to 10 inclusive for 50 minutes; and trees 11 to 15 inclusive for 41 minutes.

Schedule D1—dried in the same dryer as was used for Schedule B1, but to the Douglas-fir sapwood schedule, maximum temperature 355° F., for the following times: trees 1 to 5 inclusive for 28 minutes; trees 6 to 10 inclusive for 26 minutes; and trees 11 to 15 inclusive for 29 minutes.

Schedule D2—twice through the Douglas-fir sapwood schedule (D1)—trees 1 to 5 inclusive for a total of 57 minutes; trees 6 to 10 inclusive for a total of 51 minutes; and trees 11 to 15 inclusive for a total of 66 minutes.

One three-ply panel was prepared for each tree and each drying schedule. The hot-press phenolic-resin adhesive currently in use at the plywood factory was spread in a laboratory glue spreader, and panels were pressed according to manufacturer's specifications. From each panel 22 Glueline-Cleavage specimens and 2 Plywood Shear specimens were prepared. Five of the Glueline-Cleavage specimens were tested dry without any pre-test treatment. Ten of the Glueline-Cleavage specimens and the two Plywood Shear specimens were tested wet after the boiling-drying-boiling treatment commonly prescribed for Exterior Grade Douglas-fir plywood. The remainder of the specimens were subjected to repeated boiling and drying to simulate exposure to the elements. In all cases, with the exception of the "accelerated weathering" specimens, both breaking loads and percentage wood failure were recorded.

Analysis of Test Results

The results of these tests, with the exception of the delamination tests, have been reduced to percentages for ease of comparison, and are presented in Table 3. The delamination test results have been reported as "demerit numbers", a "demerit number" for the purpose of this report being defined as the sum of the quotients

$$\frac{\text{(number of specimens delaminated)}}{\text{(number of cycles for delamination to occur)}}$$

on the theory that any reduction in bond quality is proportional to the number of specimens which delaminate and inversely proportional to the number of cycles of drying and boiling which caused the specimens to delaminate. In Table 3 the drying schedules have been arranged from left to right approximately in the ascending order of severity.

The Glueline-Cleavage breaking loads, tested dry, and the Plywood Shear breaking loads, tested wet, were subjected to analysis of variance. In Table 3 one asterisk indicates significance at the 5 per cent level and two asterisks indicate significance at the 1 per cent level. Breaking loads of Glueline-Cleavage tests of dry specimens and of Glueline-Cleavage and Plywood Shear tests of specimens tested wet (after 4 hours' boiling, 20 hours' drying, and 4 hours' boiling) indicated average reductions in breaking load of 22, 30, and 32 per cent respectively for veneers which had been subjected to the most severe drying schedule (twice through the Douglas-fir sapwood schedule). Average wood failures of the same specimens were reduced respectively by 57, 58, and 50 per cent.

Considerable variability between trees was noted. Based upon breaking loads, the percentage reductions for individual trees ranged from zero to 76 per cent, and when based upon percentage wood failure, from zero to 100 per cent. It appears that certain trees were not affected by drying schedules as severe as twice through the Douglas-fir sapwood schedule, while others were very severely affected.

Considering the high degree of variability usually associated with wood and glue-joint testing, the pattern of results is surprisingly uniform. There are some differences in the order in which different tests have rated the effects produced by different drying schedules, but all methods separate the very good from the very bad. The fact that seven combinations of test and pre-test treatment all yield the same pattern of differences emphatically confirms the pattern indicated by each method.

[6] Project V-30-5—An Investigation of the Use of Adhesive Strength, Accelerated Weathering Cycles, and Specimen Design as Tools to Improve the Reliability of the Interpretation of Mechanical Tests of Wood-to-wood Bonds. (Unpublished). Vancouver Forest Products Laboratory.

It is evident that certain of the drying schedules produced plywood of lower bond strength than that produced by the other schedules. The most severely degraded veneers were those which were subjected to the most severe drying schedules, notably Schedules A2, B2, C2, and D2 (A2 being dried in the hot-press at 350° F. to oven-dry plus 30 minutes; B2, twice through the Douglas-fir heartwood schedule; C2, twice through the cottonwood schedule; D2, twice through the Douglas-fir sapwood schedule). These results confirm the conclusion that breaking loads are reduced by drying at high temperatures for long periods and provide evidence that this defect may occur in plywood factory veneer dryers.

The percentage wood failure data confirm that the defect under study is indicated by reduced wood failure as well as by reduced breaking loads. The parallelism of the wood failure and breaking load results suggests rather stronger correlation between percentage wood failure and breaking load than had been suggested by the data of Part 1.

The correlation between wood failure and breaking load was therefore investigated further with interesting results (5). It was discovered that, while the correlation between individual test results was low, the percentage correlation increased to a usable level if the means of approximately 10 tests were used—each of the 10 specimens, of course, having been subjected to the same treatment combination.

The correlation between wood failure and breaking load provided a satisfactory explanation of why this defect had been reported at the factory on the basis of wood failure and was later studied at the laboratory on the basis of breaking loads. It did not, however, answer the question "Were the suspect glue bonds due to reduced strength of the wood or to a breakdown of adhesion?" In order to do so, still another investigation was undertaken. This was a microscopic examination of the specimens which had exhibited low wood failure when judged by the industry standard. It was discovered that failure had occurred through the cell walls of the wood rather than through the glue.

Conclusions

Putting all of the evidence together, it is concluded

1. That the strength of Douglas-fir veneer is reduced by drying at excessively high temperatures.

2. That the strength of these veneers is reduced by drying for excessively long times at these high temperatures.

3. That these drying conditions cause reduced wood failure in phenolic-resin bonds when the wood failure is measured by the industry standard of wood failure.

4. That the low wood failure, as recorded by the industry standard, is not due to any loss of adhesion, nor to any decrease in the cohesive strength of the glue, but is due to the reduced strength of the wood. It is reasoned that this reduction in strength of the wood is most severe in the fibers at the surface of the veneers, and that this tends to produce very shallow wood failure. It is further reasoned that this shallow wood failure, aided by the darkened color of the degraded wood, gives the impression of glue failure when graded by the industry standard.

It is not intended to imply that the industry standard leads to faulty conclusions from a manufacturing point of view, quite the contrary. For quality control purposes, classifying these bonds as glue failure is sufficiently accurate, because it indicates that all is not well.

5. Veneers from different trees are affected rather differently by severe drying schedules, some being much more severely degraded than others.

6. Veneers from trees grown in different localities followed the same behaviour pattern.

Comments

In October 1950, the University of British Columbia Forest Club published a summer essay by E. J. Kuffner, based upon the exploratory investigations (Part 1) of this problem, under the title, "Tests of Glue Strength of Douglas Fir from Northern Interior and Coast Areas". In October 1953, Dr. Ben S. Bryant and R. K. Stensrud presented a technical paper before the Pacific Northwest Section of FPRS under the title. "Some Factors Affecting the Glue Bond Quality of Hard-grained Douglas-fir Plywood" (Jour. of FPRS IV-(4):158.) To the best of the author's knowledge, these are the only published papers which have dealt with this problem.

The research of Bryant and Stensrud is quite compatible with the theory set forth herein that the inferior bonds produced by drying at high temperatures (or long periods) are attributable, not to interference with the bond, but to the degradation of the wood strength. Bryant and Stensrud confirm that lower drying temperatures yield better bonds. Four of the five glues gave wood failures which indicated

Table 3.—PERCENTAGE BOND QUALITY OF PHENOLIC-RESIN BONDED DOUGLAS FIR VENEERS, PRODUCED BY OVEN-DRYING VENEERS IN COMMERCIAL VENEER DRYERS, AS RECORDED BY SEVEN INDEPENDENT METHODS OF TEST

METHOD OF ESTIMATING BOND QUALITY	DRYING SCHEDULE										
	Dried to Zero Moisture Content in Oven at 225° F.	Once Through Veneer Dryer with Douglas fir Heartwood	Dried at Zero Moisture Content in Hot-press at 350° F.	Once through Veneer Dryer with Cottonwood	Dried to Zero Moisture Content in Oven at 350° F.	Once through Veneer Dryer with Douglas Fir Sapwood	Twice through Veneer Dryer with Cottonwood	Twice through Veneer Dryer with Douglas Fir Heartwood	Dried to Zero Moisture Content plus 30 Min. in Hot-press at 350° F.	Twice through Veneer Dryer with Douglas Fir Sapwood	Number of Specimens Tested
	A4	B1	A1	C1	A3	D1	C2	B2	A2	D2	
Glueline-Cleavage, Breaking Loads, Tested Dry†	98	100	82**	93*	94*	92**	89**	85**	75**	78**	750
Glueline-Cleavage, Breaking Loads, Tested Wet	100	97	89	96	91	92	87	83	75	70	1500
Plywood Shear, Breaking Loads, Tested Wet	100	100	89*	92	87**	82**	80**	78**	73**	68**	300
Glueline-Cleavage, Per cent Wood Failures, Tested Dry	100	92	86	82	75	73	55	56	52	43	750
Glueline-Cleavage, Per cent Wood Failures, Tested Wet	100	89	89	81	71	80	58	67	43	42	1500
Plywood Shear, Per cent Wood Failures, Tested Wet	100	81	96	80	78	79	66	67	52	50	300
Demerit No.‡ obtained from the specimens which delaminated under repeated boiling and drying—the higher the number the poorer the bond	0.11	0.72	0.59	2.94	4.76	5.29	8.09	8.59	11.53	21.84	1500

*Indicates significance at the p = .05 level.
**Indicates significance at the p = .01 level.
†In order that they may be compared directly, breaking loads and wood failures have been reduced to percentages of their appropriate maxima.
‡Results of delaminations caused by repeated boiling and drying are recorded by "demerit numbers". A "demerit number" is defined, for the purpose of this report, as the sum of the quotients "No. of delaminated specimens"

$$\frac{\text{No. of Cycles}}{\text{No. of Cycles}}$$

that veneer dried at the lower temperature gave better bonds than did those dried at the higher temperature. With the fifth glue there was no significant difference between the wood failures.

If the theory is correct, and the defect is attributable to the reduced strength of the wood, then all glues would be expected to follow approximately the same pattern. One way in which the pattern might not be followed would be when an adhesive penetrated the wood so deeply that it reached into the stronger portions of the wood and reinforced the weaker portions. If this explanation for the one deviation from the pattern is accepted, the five glues used in this work appear to reaffirm the hypothesis stated in this paper.

The better bonds noted for heartwood, as opposed to sapwood, can likewise be explained on the basis of this hypothesis. It is customary practice for sapwood veneers to be retained in the dryer at the same temperatures as heartwood but for a longer period of time. The sapwood veneers are therefore subjected to a more severe degrading influence than heartwood veners and would, according to this hypothesis, be more severely reduced in strength than the heartwood veneers. This would logically result in poorer bond quality for the sapwood veneers as has been recorded by Bryant and Stensrud.

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Management Possibilities With Quality Control Methods[1]

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The broad applicability of statistics in industrial management and the fundamental contributions of a statistical program are discussed. Areas of suggested applications are listed, with bibliographic references given for most types. An example is given of a study of inventory control methods, with its resulting values to the company.

THE MANAGEMENT POSSIBILITIES in quality control methods lie not only in the use of control charts and other simple tools to control manufacturing processes but to an even greater extent in an analytical approach to the management of whole enterprises. Quality problems are not the only problems facing a plant manager, who must also keep abreast of production schedules, keep costs as low as possible, and maintain industrial relations at a high level. Moreover, plant problems are only a part of the problems of a complex industrial organization, which must also manage successfully in other areas such as purchasing, maintenance, sales and servicing, and research and development.

The consequence is that many times a beginning interest in production quality control grows and grows until a system is developed which handles problems as diverse as design of experiments, administrative controls, linear programming, and operations research—in short, a system of industrial statistics. It is right and proper that this is so because all of these areas present problems to management, all are related, and all can benefit, even from the simplest of the quality control techniques. It is quite apparent to modern management that the ability to analyze the masses of information put before it is essential to progress.

Table 1.—AREAS FOR APPLICATION OF QUALITY CONTROL

Absenteeism
Budgetary and Cost Accounting Records (Current Ratio, etc.)
Clerical Work Standards
Cost Analysis
Credit Conditions (Overdue as Per cent o Total Receivable, etc.)
Economic Indices
Error Rates
Estimating Accuracy
Expense Ratios
Inventory Discrepancies
Merit Ratings
Overtime Pay Rates
Personnel Performance
Production Time Lost
Sales Rates
Sickness Rates
Traffic Data
Wage Schedules

One of the most useful keys to analysis is the straightforward simplicity of the basic quality control techniques.

An Exemplary Statistical Program

An example of broad understanding of the fundamental contributions of quality control methods is the plan devised by an industrial executive for a new quality control organization in his company. This quality control organization has broad areas of responsibility covering most of the major administrative concerns of the company.

A process control section has the responsibility for going out into the plant and designing, installing, and initially operating statistical quality control on one production line after another. Opposite numbers from the plant are assigned to each quality control engineer with a view to the operation being taken over by the plant at the earliest practicable moment and expanded throughout all details of its operation.

A second section has the responsibility for quality assessment. It uses the good quality records created by the institution of statistical quality control in the manufacturing operations. It is ever ready to supply a quality assessment of all the company's products. By directing experiments in the company's laboratories, it is able to compare the quality assessment of the company's products with those of competitors.

[1] Presented at Session I, Quality Control, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] When this paper was presented, the author was Chief, Design of Experiment Unit, Research and Development Division, Office, Chief of Ordnance, Washington 25, D. C.

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A third section is an operations research group which runs administrative applications of statistical quality control, phases of market analyses, prediction of long-term trends, market and product improvements, and is able to supply sound data and predictions with respect to probable pay-off of ultimate lines of endeavor. It also advises on shaping policies for management of the company.

This is a very forward-looking program and possibly few companies have a plan as ambitious as this one. However, it might not be a bad plan for many more managements to emulate.

Areas for Quality Control Application

To become a bit more specific about the types of problems of a management nature to which quality control techniques may be applied, Table 1 lists suggested applications.

Over the period of several years in which there has been activity in using quality control in these areas, almost all of the subjects on the list have been treated in the literature. That this is the case is demonstrated by the broad coverage represented in the Bibliography appended to this paper. Among this not inconsiderable list, not many types of application have escaped attention.

An Application to Inventory Control

One type of administrative application that has not received much publicity is the study of inventory control problems. Some time ago, the author was involved in a determination of optimum inventory size and of economic re-order points for a distribution operation of considerable size. This operation involved 12 different products distributed from four warehousing points in the East and Middle West. A great deal of the study involved, of course, the enumerative approach ordinarily thought of as the domain of the business statistician. However, very critical parts of the analysis of the data were accomplished, in this instance, by the use of Shewhart control chart principles.

The products were bulk materials shipped in drums and accounting was made on the basis of the pounds shipped. Data were available for at least 12 months, in some instances for as many as 18 months, on the number of pounds of each of the 12 products shipped from each of the four warehouses.

The second column of figures in Table 2 shows the total actual monthly shipments of a typical product from one warehouse. Obviously, these figures vary so much that no sound statistical forecast could be made on the basis of these data alone. Actually, in the past, inventory levels had been established on the basis of accumulated forecasts by sales territories. This was generally unsatisfactory, however, partly because of the perennial optimism of salesmen, partly because no really systematic use of data was being made to determine optimum inventories, and partly because warehouse districting was in need of revision. It had been common practice to tranship between warehouses or to ship across warehouse district lines to fill rush orders. As a result of these undesirable conditions, during the most recent period the over-all turnover had been only 3.3 times per year.

Table 2.—TOTAL SHIPMENTS IN POUNDS—WAREHOUSE 1—PRODUCT H

Month	Actual Shipments	Logical Shipments	Moving Range
July	16,650	11,700	------
August	11,250	11,700	0
September	44,100	19,800	8,100
October	13,050	15,766	4,034
November	30,600	25,200	9,434
December	24,300	11,700	13,500
January	40,500	27,000	15,300
February	12,150	28,350	1,350
March	36,450	18,000	10,350
April	29,250	8,675	9,325
May	19,350	16,200	7,525
June	29,700	13,950	2,250
July	31,950	13,050	900
Totals	339,300	221,091	82,068
Averages	26,100	17,007	6,839

As a first step in the analysis, it was decided to re-allocate all shipments for the period for which data had been accumulated on the basis of the logical shipments from each warehouse. A logical shipment was one which minimized the shipment cost and eliminated the need for transhipments from warehouse to warehouse.

In making this re-allocation it was decided that a considerable portion of the total shipments, including all car lot shipments, could be made directly from the plant which was located near one of the larger centers of use, without intervening warehouse storage. The resulting logical shipments for the typical product used as an illustration are given in the third column of Table 2.

The variation in logical shipments was much less than in the actual shipments and some statistical analysis seemed possible. Accordingly, for each set of data, control chart limits were computed based on the moving range of consecutive monthly figures. Typical range computations are given in the final column of Table 2. Control chart limits for individuals and ranges were then computed, as follows:

Individual limits: $\overline{\overline{X}} \pm E_2 \overline{R}_M = 17{,}007 \pm 2.66 \times 6839 = 17{,}007 \pm 18{,}192 = 35{,}199$ and 0

Range limits: $D_1 \overline{R}_M$ and $D_2 \overline{R}_M = 3.267 \times 6839$ and $0 = 22{,}343$ and 0

These are very wide limits due to the variability still present in the estimates of logical shipments but they do indicate that it is not too unrealistic to use the moving range data to determine optimum inventories, at least on a preliminary basis. It was decided that in each case an inventory should be maintained capable of meeting 90 per cent of the demands on the warehouse. The standard deviation of the logical shipment data from Table 2 is given by $s = \overline{R}_M/d_2 = 6839/1.128 = 6063$ with 12 degrees of freedom. An upper bound which will guarantee meeting 90 per cent of the demands is given by $\overline{\overline{X}} + ts = 17{,}007 + 1.78 \times 6063 = 17{,}007 + 10{,}792 = 27{,}799$.

This was rounded downward to 27,000 pounds which is considered to be the optimum inventory figure. This gives a turn-over rate of 7.5 times per year compared to the old over-all rate of 3.3. If there had been a marked trend in sales volume or if sales had fluctuated seasonally, it would have been necessary to apply appropriate corrections. However, this was not

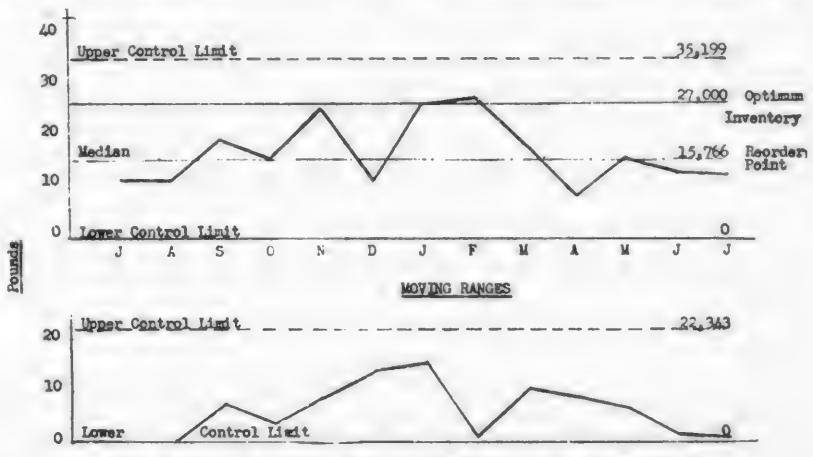

Fig. 1.—Logical monthly shipments—Warehouse No. 1—Product H.

Table 3.—NUMBER OF SERIOUS INJURIES

Personnel Group	4th Qtr. 1953	4th Qtr. 1954	Percent Change	3rd Qtr. 1954	4th Qtr. 1954	Per cent Change
A	4	3	— 25	1	3	+200
B	4	0	—100	0	0	0
C	0	4	+100	1	4	+300

done and when the optimum inventory levels had been obtained as described for each material at each warehouse, the total optimum inventory at the four warehouses turned out to be 417,000 pounds compared to the previous peak inventory of 681,500 pounds, a reduction of 39 per cent. The new turnover rate was estimated as 4.0 times per year compared to the old rate of 3.3. Furthermore, the total annual volume handled by the warehouses was reduced by 38 per cent due to the practice of shipping to the local area or elsewhere by car lots direct from the plant.

Another desirable figure was the proper re-order point and this was arbitrarily set at the median logical monthly shipment size. Control charts, like the one for the example shown in Fig. 1, portrayed all of the pertinent information graphically and assisted in the analysis of each situation.

No system may be devised which will work perfectly under all conditions and it was expected that this system would be subject to adjustment upward or downward for known seasonal fluctuations or for unusual changes in normal orders during a given month.

An Example from Safety Statistics

Many of the articles in the bibliography discuss the use of control charts. Both to afford an opportunity to illustrate the use of other techniques of industrial statistics and to present unhackneyed material, an example has been chosen from the field of safety statistics. This is an area in which prejudices against statistical interpretation seem to be very deep-rooted. However, it is believed to be worthwhile to point out some of the inconsistencies in non-statistical interpretation and the advantages, in terms of assurance of being right, in a correct statistical approach.

Table 3 shows the number of serious injuries experienced by three different groups of personnel, parts of a large organization, at different time periods. The data are given exactly as reported, although one of the purposes of the discussion will be to point out the shortcomings of the per cent change information that is given.

The following facts are evident from Table 3:

1. The number of serious injuries in Group B showed a considerable decrease during the fourth quarter of 1954 as compared to the same period in 1953.

2. The number of Group C injuries showed a considerable increase during the fourth quarter of 1954 as compared to the same period in 1953.

3. The number of injuries for both Group A and Group C showed some increase for the fourth quarter of 1954 over the third quarter of 1954.

4. If the total number of injuries is computed, it may be observed that nine occurred during the last half of 1954, of which two occurred during the third quarter and seven during the fourth quarter.

The above data were analyzed in an attempt to determine whether the differences in the number of injuries from quarter to quarter reflect significant changes or whether the differences may simply be due to chance. The first analysis was to determine whether the two injuries during the third quarter of 1954 differ from the seven injuries during the fourth quarter of 1954 at the 95 per cent level of significance. To conduct the statistical test, it will be hypothesized that 50 per cent of the nine injuries would have occurred in each quarter had there been no differences between quarters. Reference should be made to a 95 per cent table of binomial confidence limits.[3] From this table, it may be observed that for $x = 2$ and $(n-x) = 7$, the confidence limits include 50 per cent. It is therefore concluded that, based upon statistical considerations only, at the 95 per cent level there is no significant difference between the two injuries in the third quarter and the seven injuries in the fourth quarter.

All other cases in which an increase or decrease in the number of injuries was indicated in the table were also investigated. In every case the difference was not significant at the 95 per cent level. This conclusion is equivalent to stating that, if nothing is available but the information in the table, one would not be justified in concluding that any great change in the causes of injuries (extreme carelessness for example) has occurred from one quarter year to another.

The columns headed "Per cent Change" in the table are rather meaningless and not always accurate. These percentages are meaningless because of the small number of injuries in each case. A second reason why this is true is illustrated by the following example: suppose the number of injuries increases from one to four from one quarter to the next; this is an increase of 300 per cent. Now suppose that the number decreases to one for the next quarter; this is a decrease of 75 per cent. Clearly there is a great discrepancy between these two percentages, yet in terms of the number of injuries, we are right back where we started. An example of an incorrect value is that obtained upon going from zero to four injuries an increase of 100 per cent was indicated; however, the value of percentage increased should be infinity.

[3] See for example: Hald, A. 1952. Statistical tables and formulas. John Wiley and Sons, New York. p. 66.

Improving the Possibility of Correct Decisions

Every management is faced daily with a large number of such problems requiring exercise of judgment regarding the kind of action that is to be taken. Considered singly, the implications of wrong or of doubtfully correct conclusions may not seem to be too serious. However, the success record of management is based upon the cumulative effect of many decisions both small and great. The over-all record of management depends on being right most of the time. Most of the time may need to be practically all of the time to mean success from the standpoint of individual executives.

It is, therefore, very important, from the standpoint of both the organization and individual executives, to use every known tool which will improve the quality of decisions. It should become more and more evident that the quality control tools provide management with many possibilities for achieving a good record of correct decisions.

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Discussion

David E. Wilson, III (Owens–Illinois Plywood Co.): Could you give some pointers in setting up quality control systems for small and medium sized plants?

Mr. Bicking: The problems associated with these sizes of plants are not much different from those in larger plants. In either case, management must be sold on the program. The ways of starting a program are two. Either a man within the organization who knows quality control or an outside consultant who knows quality control must be used to start the work. The man must be well-versed in the ways of quality control. The simplicity of quality control methods has been oversold. The math is not rigorous, true; but the trick is to recognize the problems and apply correct methods of collection and grouping of data in generating charts for good information. To do this is difficult and a strong source of technical information and guidance is needed to answer the sticky questions that will arise.

Milton H. Mater (Mater Engineering Co.): What relationship in number of samples required exists when a feed-back control system is used as compared with a machine in which no feed-back system is used? We are trying to set up such a feed-back system to correct for lumber thickness on the sawmill carriage.

Mr. Bicking: There are three aspects to consider in this problem. 1) You may just have to use a trial and error method in order to live with the problem. 2) Since you usually don't know the properties of the population in the beginning, some sampling must be done to gather background data. Once the characteristics of the population are known, then the optimum sampling number for any system can be determined. 3) Until we know whether the variability is random or non-random a reliable sampling scheme cannot be constructed. Work must be done to find out if the variability exists among groups or within groups. The second aspect probably has most bearing on the question.

R. C. Calahan (Singer Manufacturing Co.): I gather you feel operations research and quality control should be a combined group; if so, what do you feel is its place in the organizational structure of a multi-plant company?

Mr. Bicking: Many quality control operations are very close to what is known as operations research; so close that the difference is largely in semantics. Good operations research can be an outgrowth of a good quality control program because it simply means extending many of the principles upon a broader management base.

A. C. Barefoot (N. C. State College): What type of program have you found successful in introducing and selling quality control to management and to production?

Mr. Bicking: An educational program is essential. An important part of that program must be demonstration of usefulness in problems actually facing management or production. In the long run, nothing will succeed like a little success.

Factors Affecting the Quality of an Epoxy Resin Wood-to-Wood Bond[1, 2]

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A single epoxy resin formulation was evaluated to determine the effect of curing temperature, rate of spread, assembly time, and age of glue line on the strength of the glue line in shear. The water resistant qualities of the glue lines of the different temperature, rate of spread, and assembly time treatments were also studied.

Introduction

A RELATIVELY NEW CLASS of synthetic resins which have been developed since World War II are the epoxies. This family of plastics has received a great deal of attention because of the properties of the cured resin, and has promise of becoming the fourth class of synthetic resins in the adhesive field. It is beyond the scope of this paper to discuss in detail the chemical composition of epoxy resins or why the cured resin possesses the characteristics that are attributed to it.

The 1952 Edition of the *Modern Plastics Encyclopedia and Engineers Handbook* (2)[3] has this to say concerning epoxy resins:

> "The basic ingredient of these resins is a compound containing oxygen linked in a chain of carbon atoms to two of these atoms, such as epichlorohydrin $CH_2CH_2CH_2Cl$ (with the O bridging the two middle carbons).
>
> "During the resin formation the oxygen rings open, leading to the formation of linear polymers. The presence of a third reactive group in the epoxy compound or in other added ingredients leads to crosslinking and the resultant thermosetting properties. These resins give strong bonds to many organic and metallic materials and are especially useful for bonding nonabsorbent substances without pressure. Curing may be accomplished at room temperature or more rapidly at temperatures up to 390° F."

The properties of the epoxies according to Preiswerk (11) are as follows:

1. A minimum of shrinkage during hardening.
2. High adhesion to most materials.
3. Practically no elimination of fugitive materials.
4. High mechanical strength.
5. Resistance to most common chemicals.
6. Good dielectric properties.

Epoxy resins have been claimed to be a triple-threat resin because they can be used as: (1) casting and potting resins due to their low shrinkage, high mechanical strength, and good dielectric properties; (2) surface coatings because of their high adhesion to many materials, chemical resistance, and film forming characteristics; and (3) as adhesives because of their high adhesion to most materials. The use of these resins as adhesives is a field of speculation and promise. Technical information pertaining to the quality of the bond formed by an epoxy adhesive between various materials appears to be meager. Available data are limited primarily to the use of this adhesive to adhere metal to metal (3, 5). The present high cost of this resin has been one of the main reasons that its use has been restricted to the metal and glass fields.

Information as to the strength of an epoxy glue line between wood laminae appears to be nonexistent except for statements by the various manufacturers that this adhesive will bond wood to wood. In addition, no specifications for using epoxy adhesives to bond wood to wood seem to be available (7). Since such basic information is lacking, it was thought to be worthwhile to evaluate an epoxy-resin formulation when used as an adhesive in an effort to determine the conditions that are necessary to produce an optimum wood-to-wood bond.

The hardener used to cure the resin affects the properties of the cured resin because it completely enters into the final reaction (13). This being the case, each resin-hardener combination will yield a cured adhesive with different properties. It was beyond the scope of this investigation to test all the epoxy adhesives which are available. Therefore, the initial problem was to select one epoxy formulation to test as a wood adhesive.

The adhesive chosen for evaluation was selected as the result of a preliminary investigation of three epoxy resin formulations. The adhesives, Hysol 2515 with hardener E, Hysol 2540 with hardener X, and Hysol 2020 with hardener C, were supplied by the Houghton Laboratories of Olean N. Y. The formulations were evaluated by testing the shear strength of the glue line as described in ASTM Standard D 905–49 (1). The results of this investigation indicated that Hysol 2020 with hardener C showed the most promise as a wood-to-wood adhesive, and therefore merited a more detailed study.

Hysol 2020 is a two-component adhesive consisting of a resin and a hardener. The adhesive is capable of curing at room temperature when the resin and hardener C are mixed in the proper proportions. The resin and hardener are pale yellow in color and of medium viscosity.

The objectives of this study were to determine the following for a single epoxy resin formulation.

1. The effect of curing temperature, rate of spread, assembly time, and age of glue line on the strength of the glue line in shear.
2. The water resistant qualities of the glue lines of the different temperature, rate of spread, and assembly time treatments.

The standard block shear test as described in ASTM Standard D 905–49 (1) was used in order to evaluate the strength of the glue line in shear. The durability of the glue line was tested by an accelerated weathering technique described by Freas and Selbo (7).

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[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

[2] Authorized for publication in the Journal Series of the Pennsylvania Agricultural Experiment Station as paper number 2033, Dec. 17, 1955.

[3] Numbers in parentheses refer to literature cited.

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Procedure

Design of Experiment: In order to extract as much information as possible about this adhesive from a single experiment, the effect of four variables on the strength of the glue line in shear was investigated. These variables were curing temperature, rate of spread, assembly time, and the age of the glue line at time of test. These particular variables were selected because they are important to the user of the adhesive.

The experimental design used is shown in Fig. 1. Each block of this design represents one laminate assembly given a specific curing temperature, rate of spread, assembly time, and age treatment. In order to gain accuracy, four block shear specimens were manufactured from each lamination. This enabled the shear strength of the glue line to be replicated four times for each treatment. A design of this type enables the effect of the variables on the shear strength of the glue line to be analyzed by the techniques of the analysis of variance (5, 12).

It is recognized that factors other than those noted will affect glue line strength; however, if they were to be included in this study, the collection and analysis of the data would become expensive and the results would be difficult to interpret in other than theoretical, statistical terms. All variables not under investigation were held constant, or allowed to enter into the experiment in a random fashion.

Specimen Preparation: Maple blanks, 12 in. by 2½ in. by ¾ in., were used to form the laminations. Hard maple was selected as the species to be used because it is capable of developing relatively high shear strength, and it is a dense wood that is rather difficult to glue. Only defect-free, straight-grained laminae were used. Two blanks were matched by weight to form a laminate assembly. The weight of each blank was within five grams of its mate. In order to avoid bias due to specific gravity, the treatment for each laminate assembly was assigned by use of a table of random numbers.

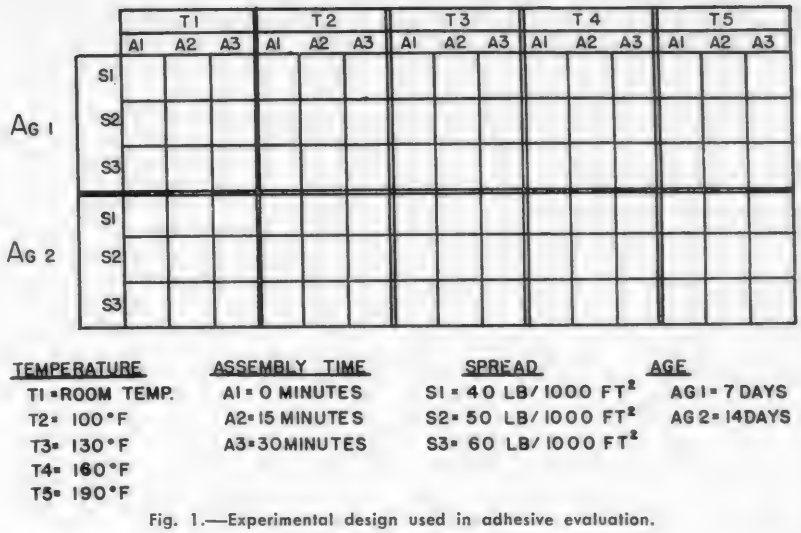

Fig. 1.—Experimental design used in adhesive evaluation.

Results and Analysis

Block Shear Tests: The data collected at test included total load, shear strength, and per cent wood failure for each of the test specimens and a representative moisture content and specific gravity determination for each treatment. These data are reported in detail by Clarke (4).

While it is possible to analyze the results of this experiment by means of a single analysis of variance, such an analysis would be extremely difficult to interpret because of the numerous interactions involved. As an alternate procedure, the data for the glue lines aged 7 and 14 days prior to test were analyzed separately as shown in Table 1.

Table 1 shows that in both age groups there was a highly significant difference in shear strength due to the effect of temperature. There was no significant difference in shear strength due to the effects of either assembly time or rate of spread. In the case of the 7-day-old glue lines, none of the first order interactions were significant at the 5 per cent level although the temperature-spread interaction is significant at the 10 per cent level and therefore there is at least an indication that certain combinations of temperature and spread have an effect on shear strength.

In the case of the 14-day-old glue lines, there is a significant temperature-assembly time interaction. The second order interaction of both analyses is significant. In this experiment this second order interaction is a measure of the blank-to-blank variation that occurred. It should be noted that this variation is essentially the same in the two age groups.

The mean square values of Table 1 may be used as a basis for further comment. These values do not differ significantly from one another except in the case of temperature and the temperature-assembly time interaction. The mean square value for temperature of the 14-day-old glue lines is

Table 1.—ANALYSIS OF VARIANCE OF THE EFFECT OF CURING TEMPERATURE, ASSEMBLY TIMES, AND RATES OF SPREAD ON GLUE LINE SHEAR STRENGTH

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio
7-day-old glue lines				
Main effects:				
Temperatures (T)	4	56,552,822	14,138,205	52.11**
Assembly times (A)	2	904,649	452,325	1.66
Spreads (S)	2	1,606,369	803,185	2.96
First order interactions:				
T x A	8	2,966,167	370,771	1.37
T x S	8	5,417,756	677,219	2.50
A x S	4	1,939,982	484,996	1.79
Second order interactions:				
T x A x S	16	4,340,933	271,308	2.61*
Subtotal	44	73,728,678		
Within groups	135	14,050,680	104,079	
Total	179	87,779,358		
14-day-old glue lines				
Main effects:				
Temperatures (T)	4	28,336,285	7,084,071	6.57**
Assembly times (A)	2	635,094	317,547	
Spreads (S)	2	1,675,423	837,712	2.62
First order interactions:				
T x A	8	8,620,147	1,077,518	3.38*
T x S	8	3,087,169	385,896	1.21
A x S	4	1,304,170	326,043	1.03
Second order interactions:				
T x A x S	16	5,098,326	318,645	2.50*
Subtotal	44	48,756,614		
Within groups	135	17,178,490	127,248	
Total	179	65,935,104		

**Significant at 1 per cent level.
*Significant at 5 per cent level.

only approximately half as large as it is for temperature in the 7-day-old glue lines. This would indicate that some factor was present in 14-day-old glue lines that caused a reduction in the influence of curing temperature on the strength of the glue lines. This factor also influenced the interactions and became most apparent in the temperature-assembly time interaction of the 14-day-old lines. These two analyses indicate that it is not possible to group the two age classes.

Since the only significant main effect in Table 1 was that having to do with temperature, it becomes possible to deal with the overall effect of this factor. The average shear strengths for the curing temperatures for both age groups are presented in Table 2.

A comparison of these values with published shear values of sugar maple at 8 per cent moisture content is shown in Figure 2. These data indicate that shear strength increases with temperature and that at the lower curing temperatures an increase also occurs as a result of aging. In order to examine this information more thoroughly, use was made of the analysis of variance, Table 3.

Table 3 indicates a significant difference due to temperature, no significant difference due to age, and a highly significant temperature-age interaction. The cause of this interaction is apparent in Fig. 2. As a result of aging, all glue lines increased in strength except those cured at 160° F. At this temperature the 14-day-old glue lines resisted a lower stress in shear than did those aged for 7 days. Use was made of the just-significant difference (12) in order to determine at what curing temperatures a significant change in shear strength was brought about due to aging, Table 4.

There is no real difference in shear strength due to aging the glue lines cured at 190° F. All other curing temperatures showed a significant change in shear strength as a result of aging.

The effect of aging on the strength of the glue line in shear when classified on the basis of temperature is difficult to interpret because of the results of the 160° F. cure. For this temperature the glue lines aged 7 days had significantly higher shear strengths than the glue lines aged approximately 14 days. It is hard to believe that age would cause a decrease in the shear strength at this temperature, since the shear strength of the glue lines increased with age for the three lowest curing temperatures and remained the same for the highest curing temperature.

The shear strengths have not been adjusted for moisture content of the wood at time of testing. The difference between the age classes could have been caused by the higher shear strengths being a result of a lower wood moisture content. According to Freas and Selbo (7), for each 1 per cent decrease in moisture content the shear strength will increase by 3.9 per cent or about 95 psi for sugar maple. The difference between the average moisture contents of the two age classes at the 160° F. cure is 0.48 per cent. Adjusting the shear values for this moisture content difference indicates that moisture content does not account for the difference in shear strength between the age classes.

The high shear values for the 7-day-old glue lines cured at 160° F. are, at present, unexplainable. It is believed that they do not represent a true sample of the population. If the shear strengths of the 160° F. cure for the 7-day-old glue lines are higher than normally can be expected, then it is thought that aging would have no effect on the shear strengths of the glue lines for this cure. Age has an effect on the glue lines initially cured below 160° F. as is shown by Fig. 3. Apparently the glue lines are not fully cured in one hour by temperatures below 160° F. and continue to cure for a rather extended period after removal from the curing chamber.

Table 2.—AVERAGE GLUE LINE SHEAR STRENGTH CLASSIFIED BY CURING TEMPERATURE AND AGE AT TEST

Temperature	Number of specimens	Shear strength (psi) $\bar{X} \pm s_{\bar{x}}$	Average moisture content (per cent) N=9	Average specific gravity oven dry weight / oven dry volume N=9
		7-day-old glue lines		
70° F.	36	1577 ± 88	7.03	.716
100° F.	36	1758 ± 164	7.41	.702
130° F.	36	2178 ± 45	8.03	.693
160° F.	36	3085 ± 63	7.64	.687
190° F.	36	2667 ± 92	8.20	.706
		14-day-old glue lines		
70° F.	36	1837 ± 63	7.31	.708
100° F.	36	2162 ± 76	7.25	.695
130° F.	36	2698 ± 74	7.62	.697
160° F.	36	2806 ± 77	8.12	.693
190° F.	36	2825 ± 92	8.65	.700

Table 3.—ANALYSIS OF VARIANCE OF THE EFFECT OF TEMPERATURE AND AGE ON GLUE LINE SHEAR STRENGTH

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio
Main effects:				
Temperatures (T)	4	78,094,711	19,523,678	11.49*
Ages (AG)	1	4,065,762	4,065,762	2.39
First order interaction:				
T x AG	4	6,794,396	1,698,599	8.63**
Subtotal	9	88,954,869		
Within groups	350	68,825,355	196,644	
Total	359	157,780,224		

*Significant at 5 per cent level.
**Significant at 1 per cent level.

Table 4.—DIFFERENCE IN GLUE LINE SHEAR STRENGTH BETWEEN AGES AT ANY GIVEN TEMPERATURE

Temperature	$\bar{X}_2 - \bar{X}_1$† (psi)	
70° F.	+250	
100° F.	+404	Just significant difference at 5 per cent level = ± 204 psi
130° F.	+520	
160° F.	−279	
190° F.	+158	

†$\bar{X}_2$ = 14-day-old glue lines.
$\bar{X}_1$ = 7-day-old glue lines.

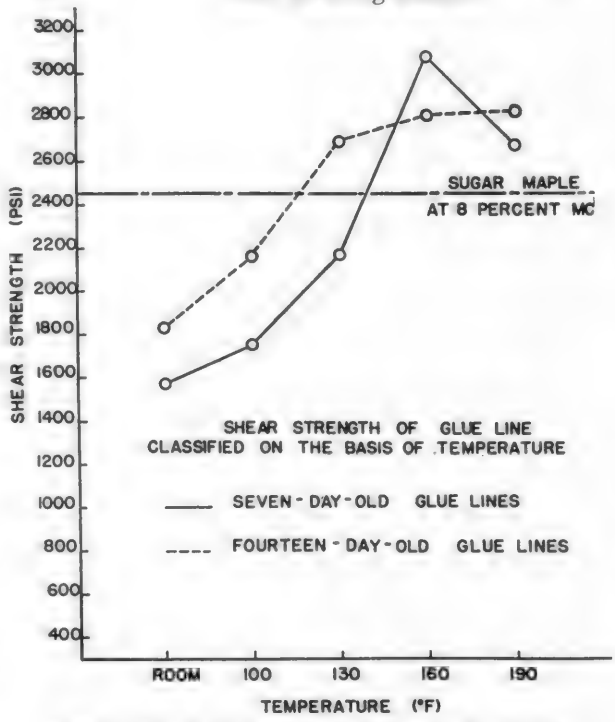

Fig. 2.—Effect of curing temperature and age on the shear strength of an epoxy resin glue line.

The information obtained through the use of the block shear test may be summarized by considering in slightly greater detail the effect of temperature, assembly time, and rate of spread on glue line strength.

Effect of Temperature on Glue Line Strength: Temperature had a similar effect on the glue line strength in both age classes. In general, the strength in shear of the glue line is increased with an increase in curing temperature. Through the use of the "just significant difference" (Table 5), it may be shown that in the case of the 7-day-old glue lines there were significant differences between each succeeding temperature; however, in the case of the 14-day-old glue lines, there were no significant differences among the 130, 160, and 190° F. groups. Significantly lower shear strengths were obtained at room temperature and 100° F. in this age group.

These differences in shear strength may be attributed to the effect of temperature and age on the degree of cure of the adhesive. Values for shear strength obtained from specimens of both age classes cured at 160° F. and 190° F. were higher than the published shear value of 2540 psi. for sugar maple at 8 per cent moisture content (6). At room temperature and at 100° F. the glue lines were only partially cured. Aging of these glue lines increased the strength in shear; however, after 14 days of aging the shear strengths of the glue lines for both of these curing temperatures remained lower than the published shear strength. It is not known at present if the adhesive cured at room temperature and 100° F. will continue to cure with a longer aging period and thereby increase the shear strength of the glue line.

The 130° F. curing temperature, after aging 7 days, produced glue lines that in general had shear strengths lower than the published shear value. Aging of the glue lines cured at this temperature increased the shear strength. At the end of 14 days the strength in shear of the 130° F. glue lines was the same as that obtained with the 160° F. and 190° F. cures following the same aging period. Since aging had no effect on the 190° F. cure., the 14-day-old glue lines of the 130° F. cure were also as strong as the 7-day-old lines of the 190° F. cure.

If there is no difference between the age classes of the 160° F. cure, as is suspected, then the glue lines cured at 130° F. and aged 14 days had shear strengths which were no different than those of the 160° F. cure after 7 days of aging. It is believed that a temperature of 160° F. for one hour completely cured the glue line.

Effect of Rates of Spread on Glue Line Strength: The results of the analyses of the effect of the rates of spread on the glue line strength were the same for both age classes. They indicated that there is no difference in the shear strength of the glue lines due to the rates of spread used in this experiment. The average shear values for the rates of spread of the 7-day-old glue lines were lower than the shear values of the 14-day-old glue lines as shown in Fig. 3. This difference is attributed to the further curing of the glue lines initially cured at the three lower temperatures.

Although the statistical analyses indicated that there was no real difference in shear strength at the 5 per cent level due to the rates of spread, it can be shown that the rates of spread are significant at the 10 per cent level for the 7-day-old glue lines and almost significant at the 10 cent level for the 14-day-old glue lines (Table 1). The combined probability is sufficient evidence to conclude that the decrease in shear strength for the 60 lb. per 1000 sq. ft. spread shown in Fig. 3 is valid and that maximum results may be obtained with this epoxy formulation with spreads of 40 to 50 lbs. per 1000 sq. ft. of glue line.

Effect of Assembly Time on Glue Line Strength: From Table 1 it has been concluded that length of assembly time had no significant effect on shear strength. The average shear values for each assembly time and age class are shown in Fig. 4. Once again the 14-day-old glue lines exhibit higher average shear values. This is the result of the further curing of the glue lines due to age. Within each age group there is practically no

Table 5.—DIFFERENCE IN GLUE LINE SHEAR STRENGTH BETWEEN TEMPERATURES WITHIN AGE CLASSES

Between $\bar{X}_1$	and $\bar{X}_2$	$\bar{X}_2 - \bar{X}_1$ (psi)	
		7-day-old glue lines	
70° F.	100° F.	+181	
100° F.	130° F.	+420	Just significant difference at
130° F.	160° F.	+907	5 per cent level = ±150 psi
160° F.	190° F.	418	
190° F.	130° F.	+489	
		14-day-old glue lines	
70° F.	100° F.	+325	
100° F.	130° F.	+536	Just significant difference at
130° F.	160° F.	+108	5 per cent level = ±166 psi
160° F.	190° F.	+ 19	

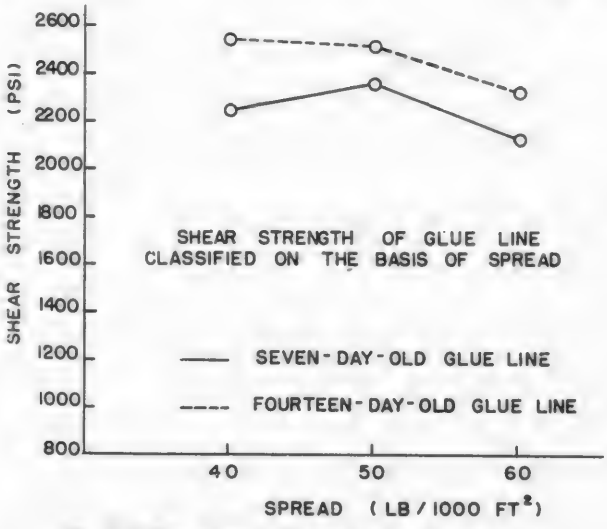

Fig. 3.—Effect of rate of spread and age on the shear strength of an epoxy resin glue line.

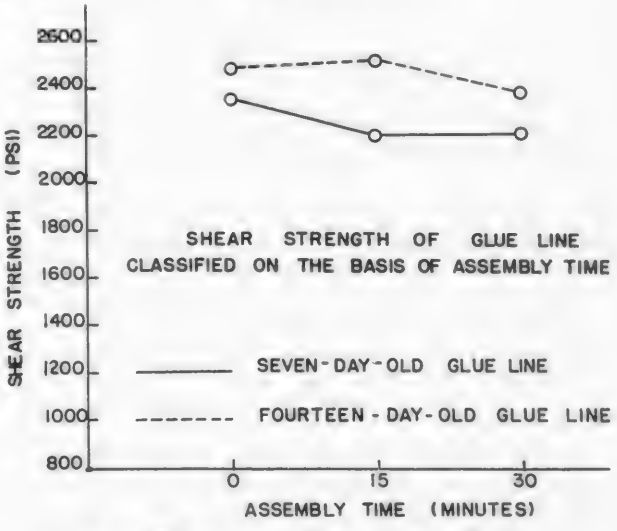

Fig. 4.—Effect of assembly time and age on the shear strength of an epoxy resin glue line.

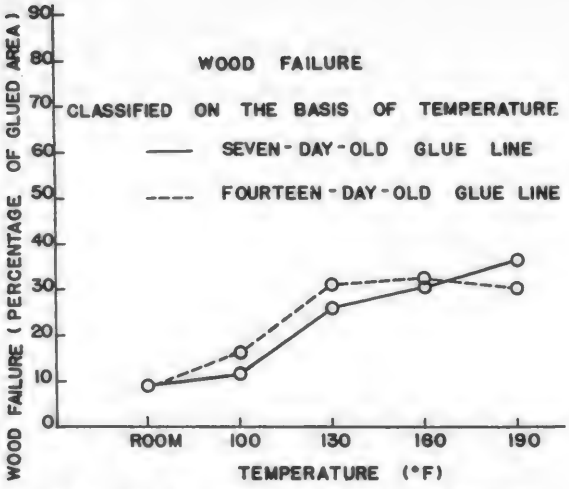

Fig. 5.—Effect of temperature and age on the percentage of wood failure shown by an epoxy resin.

change in shear strength for each of the assembly times used.

Wood Failure

The glue line of a laminated wood product when evaluated by the block shear test must satisfy specifications for shear strength and wood failure in order to qualify as a satisfactory bond. Shear strength values of the glue line should be as strong as the shear strength values of the wood and the per cent wood failure over the glue joint should average not less than 50 per cent (6).

In the preceding section it has been pointed out that for certain curing temperatures the epoxy formulation being investigated developed shear strength values equal to or higher than the published shear values of sugar maple at a similar moisture content. This section is concerned with the evaluation of the glue line on the basis of the percentage of wood failure developed over the glue joint area.

An ocular estimate of the percentage of wood failure was made for each block shear specimen. It is recognized that errors of estimation are possible with this system of measurement; however, the wood failure relationship between the various treatments should be comparable since the same individual evaluated all blocks in essentially the same fashion.

The specific gravity of the laminate assemblies must be considered when discussing wood failure. It is generally accepted that laminations made of laminae of low specific gravity produce higher wood failures than laminations made of laminae of high specific gravity. The influence of specific gravity on the results of this experiment was minimized by matching the laminae of each lamination by weight and by assigning the particular treatment for each lamination by random numbers. Because of this it may be assumed that the specific gravities of the assemblies have been dispersed throughout the treatment combinations in a random fashion.

It has been shown that in general there was an increase in the shear strength of the glue lines with an increase in the curing temperatures used in this experiment. The relationship between wood failure and temperatures follows the same trend as the relationship between shear strength and temperature. The increase in the percentage of wood failure with the increase in curing temperature for those specimens tested after aging 7 and 14 days is shown in Fig. 5.

While it is accepted that some of the variation in wood failure is due to variation in the specific gravity of the laminate assemblies it is thought that the major contributing factor is the temperature at which the glue line is cured. A highly improbable event has occurred in Fig. 5 if the wood failure is more dependent on the specific gravity of the specimens than on the curing temperature. If this were true it would mean that the laminate assemblies with the lowest specific gravities were assigned to the highest curing temperature and the laminate assemblies with the next higher specific gravities were assigned to the next lower curing temperature. This relationship would continue until the laminate assemblies with the highest specific gravities were assigned to the lowest curing temperature. It is believed that such an event did not occur because the curing temperatures were assigned at random to the lamination.

The wood failure for those specimens tested after aging for approximately 14 days followed the same trend as those specimens tested after aging for 7 days (Fig. 5). The slight increase in wood failure for the older glue line may be attributed to the further cure of the adhesive due to aging. It is evident from Fig. 5 that the wood-failure-temperature relationship is similar to the strength-temperature relationship shown in Fig. 2. In each case there appears to be no difference among the three highest curing temperatures. The type of wood failure obtained with each of the five curing temperatures is illustrated by Figs. 6 and 7.

Since the rates of spread and assembly times used in this experiment had relatively little effect on the shear strength of the glue line, no attempt has been made to show a relationship between wood failure and those variables.

While wood failure increased with an increase in curing temperature, none of the curing temperatures used developed wood failures high enough to satisfy a minimum requirement of 50 per cent. The epoxy formulation used developed high shear strength values for some curing temperatures but low wood-failures. It is similar in this respect to casein glues which Freas and Selbo report develop high shear strengths but fail to develop high wood-failures when used to bond maple laminae (7).

While estimating the percentage of wood failure for each of the block shear specimens, it was observed that cracks were present in the film of the adhesive attached to the block. Fig. 8 shows a representative sample of the blocks with these cracks present in the adhesive. The lines or cracks were observed in all treatment combinations. The lines were parallel to each other and were nearly perpendicular to the direction of the load for those specimens which showed little or no wood failure. The deviation of the parallel lines from the perpendicular was noticed in those specimens with wood failure.

Since no cracks were observed in the film of the adhesive attached to the delamination specimens (Fig. 9), it is believed that the lines in the glue film are a result of the shear stresses imposed on the glue line during test. This may be taken as evidence that unlike other wood adhesives the epoxies form an integral film between the two pieces of wood that are being glued.

Delamination Tests

This experiment was designed so that one delamination specimen could be obtained from each of the 45 laminated assemblies of an age class. Each of these assemblies was treated with a different curing temperature, rate of spread, and assembly time combination. Since the experiment was re-

peated, so that the effect of aging on the glue line strength could be determined, there were two laminated assemblies with the same combination of the variables. The piece of the laminated assembly left after cutting the block shear specimens was used to manufacture the delamination specimens. There were a total of 90 specimens, two for each temperature, rate of spread, and assembly time combination.

The procedure for testing the water resistance of the bond as described by Dreas and Selbo (7) was followed. The age of the glue lines at the time of immersion in the water ranged from 34 days for the glue lines initially cured at room temperature to 21 days for the glue lines initially cured at 190° F. Of the 90 delamination specimens, only 21 did not totally delaminate during the 15 days that they were soaked in water. Delamination occurred between most of the laminations during the first several days of soaking. After drying for approximately 24 hours in the dry kiln at 85° F to 95° F. with an equilibrium moisture content of 10 per cent, those specimens which survived the soaking in water totally delaminated.

Based on the results of this test, none of the treatment combinations satisfied the requirements for a water-resistant bond. These results indicate that Hysol 2020 with hardener C does not form a bond between maple laminae which is resistant to water. According to their manufacturers, the epoxies are resistant to most common chemicals and water (8). When the specimens, which had totally delaminated, were removed from the water the film of the adhesive composing the glue line could be removed from the wood in large pieces. A representative sample of these blocks with the detached portion of the film of the adhesive is shown in Fig. 9.

Water apparently does not affect the cohesion of the adhesive as was evidenced by the non-deterioration of the glue film during the soaking. For some reason there was a breakdown in adhesion between the epoxy formulation and the wood. The delamination of the specimens could have been caused by either a rupture of the bond by mechanical forces or by a break of the chemical linkage between the wood and the adhesive.

The complex stresses imposed on the interface of the glue line by the swelling of the wood possibly caused a mechanical rupture of the bond. Only the shear strength of the bond between maple laminae formed was investigated in this experiment. Forces other than shear are imposed on the bond by the swelling of the wood. It is possible that these forces caused a mechanical rupture of the linkage between the glue film and wood.

A break of the chemical linkage between the adhesive and the maple laminae could have caused the delamination of the specimens. When

Fig. 6.—Typical wood failures obtained with an epoxy resin. Top four blocks were cured at 70° F., bottom four were cured at 100° F.

Fig. 7.—Typical wood failures obtained with an epoxy resin adhesive. Top four blocks were cured at 130° F., bottom four were cured at 160° F.

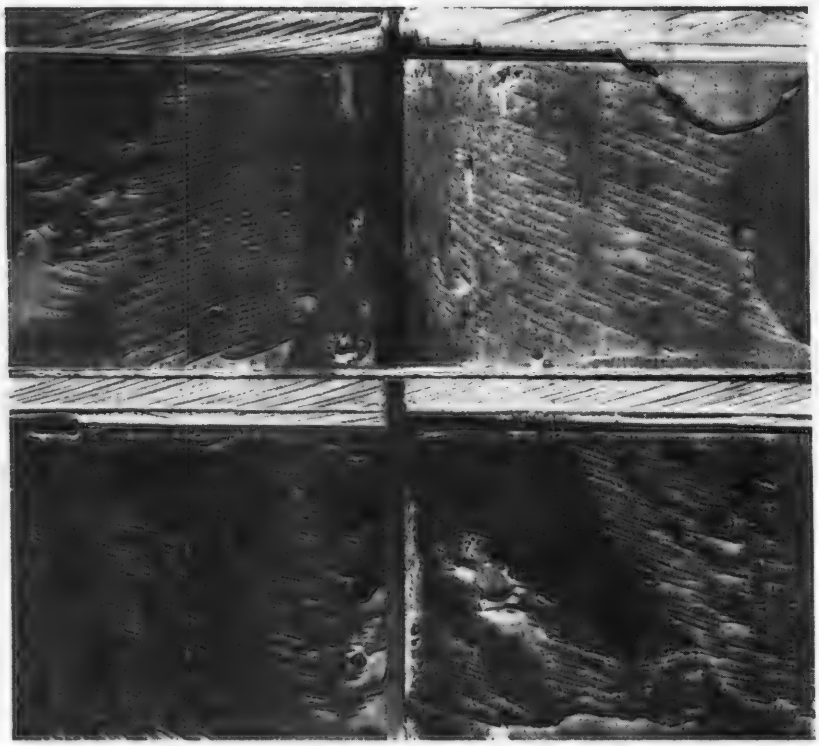

Fig. 8.—Stress lines appearing in an epoxy resin film as a result of being loaded in shear.

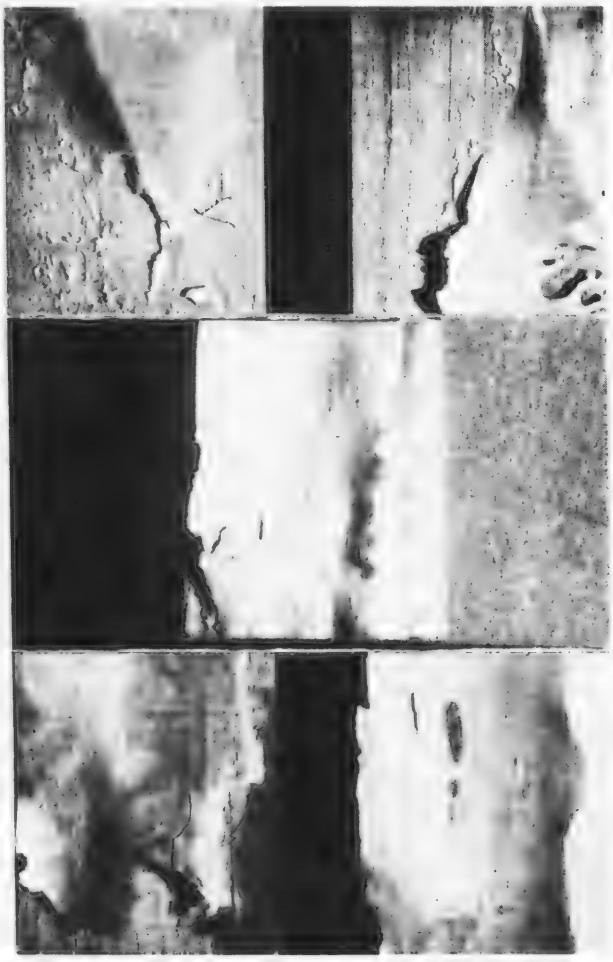

Fig. 9.—Delamination specimens showing the film formed by an epoxy resin and its subsequent detachment as a result of soaking in water.

tested in shear at approximately 8 per cent moisture content, stress values as strong as the published value for hard maple were developed for some curing temperatures and age classes. If the wood has a greater attraction for water than for the adhesive, then the chemical linkage between the wood and the epoxy formulation could have been broken by the immersion of the delamination specimens in water.

Conclusions

On the basis of this investigation the following conclusions may be drawn:

1. The epoxy formulation studied will form a satisfactory dry bond between maple laminae when evaluated on the basis of strength in shear providing it is cured for at least 1 hour at a temperature of not less than 160° F.

2. Wood failure with this particular combination of base resin and catalyst appears to be characteristically low. No combination of curing temperature, spread, and assembly time produced wood failures equal to or greater than 50 per cent.

3. Under the conditions of this experiment the epoxy formulation used will not produce water-resistant bonds.

4. Curing temperature is the most important factor in determining both the shear strength and wood failure of the resulting glue line. Curing temperatures of 160° F. and 190° F. for 1 hour will result in glue lines having shear strength equal to the published value for hard maple. Curing at 130° F. for 1 hour, 100° F. for 1 hour, or at room temperature for 24 hours will result in glue lines having progressively lower shear strengths which are less than the published value for hard maple.

5. Aging prior to test increases both the shear strength and wood failure produced by those glue lines cured at room temperature, 100° F. and 130° F. Aging does not affect glue lines cured at 160° F. and 190° F. This is evidence that an epoxy resin continues to cure over a rather extended period of time providing that the initial treatment does not produce a completely cured glue line.

6. In general the shear strength of the glue line is not affected by the rate of spread used (40, 50, or 60 lbs. per 1000 sq. ft.). There is fairly conclusive evidence that a spread as great as 60 lbs. per 1000 sq. ft. will cause a slight decrease in shear strength.

7. Open assembly times of 0, 15, and 30 minutes do not affect the shear strength of the glue lines.

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Preliminary Report on an Accelerated Soil-Burial Test Method for Evaluating the Effectiveness of Proprietary Wood Preservatives Applied by Non-Pressure Methods

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A tentative accelerated soil contact method for evaluating proprietary wood preservative formulations relative to the enforcement of the Federal Insecticide, Fungicide and Rodenticide Act of 1947 is presented. Results are given of four different preservatives applied to ponderosa and sugar pine sapwood, as dips, cold soaks, hot and cold baths, and brush and spray treatments.

Introduction

THE RESPONSIBILITY for reviewing claims made in labeling of economic poisons in accordance with provisions of the Federal Insecticide, Fungicide and Rodenticide Act of 1947 has been delegated to the Pesticide Regulation Section, Agricultural Research Service, U. S. Department of Agriculture. Labeling claims by the manufacturer must be truthful. The directions for the use of the product must be adequate to protect the public from attendant hazards, and they must be sufficiently detailed to insure effectiveness against the pests to be controlled.

Wood preservative products applied by non-pressure methods for control of fungal rots and decay have been investigated by the Pesticide Regulation Section to provide a sound basis upon which to judge the adequacy of label directions and the effectiveness of the active ingredients in respect to protection of the treated wood.

Wood preservatives have been evaluated by a number of investigators, in the laboratory by various methods, and for a variety of purposes. Schmitz et al (14)[1] have developed a Petri dish method for the determination of relative toxicities of preservatives to specific wood-rotting fungi, when incorporated with an agar medium. Hubert (7) reported an "agar-block" test method for determining the concentration of a particular fungicide necessary to entirely prevent decay in wood impregnated by partial vacuum under specified test conditions. Leutritz (10) described a "soil-block" method to determine the approximate retentions at which a material might be expected to be effective in service tests. Both the agar-block and the soil-block methods have proven useful for comparing the effectiveness of various preservatives, and for screening out ineffective compounds from those which may be of value under service conditions (5, 10, 17). Other laboratory methods of evaluating wood preservatives have been summarized in recent reviews (2, 3, 7, 12).

Actual service tests of commercial preservatives for the protection of wood in contact with the soil, such as fence posts and sills, are so time consuming that an evaluation of their effectiveness cannot be made by stake farm "graveyard" tests before the statute of limitations provided by law becomes effective.

The agar-block and soil-block test methods, as described (*loc. cit.*), require treatment of the blocks under partial vacuum to refusal of the product, followed by weathering under various conditions before exposure to pure cultures of wood-rotting fungi. Various modifications of these methods have been used in other laboratories to evaluate solvent characteristics and other factors. When these methods were modified to allow for the much more superficial treatments usually prescribed on the labels of proprietary products intended for farm and home use, it was found that the relative effectiveness of such different treatments as one or two brush or spray coats or a three-minute dip could not readily be distinguished. These methods, designed for testing thoroughly treated wood, appear to be too severe to evaluate superficial treatments.

It was therefore desirable to develop an accelerated laboratory test employing exposures mild enough to distinguish between the effectiveness of superficial treatments and duplicating as nearly as possible the conditions of

[1] Numbers in parentheses refer to literature cited.

actual use in soil contact, so that test results could be presented as evidence if necessary in the enforcement of the Act. At the same time, it was desirable to avoid the complications which develop when termites or other insects penetrate fungicidally (but not insecticidally) protected wood, thus exposing untreated wood to attack by fungi.

This paper describes a "rapid test" procedure which is suggested for evaluating wood preservatives applied by dipping, cold soaking, hot and cold baths, and by brushing or spraying as may be directed on the label, and presents results obtained with some products containing different toxicants.

Materials and Procedures

Test blocks: Ponderosa pine (*Pinus ponderosa*) or sugar pine (*P. lambertiana*) were chosen as sources of test blocks because of their availability in 2-in. random width boards of uniform growth, fairly straight grain, and relative freedom from heartwood. Boards were selected for minimum heartwood content by applying the benzidene-sodium nitrite test (9) to the ends.

The blocks used for the tests were 6 inches in the longitudinal direction (along the grain) by 1.75 inches in the radial direction by 0.5 inch in the tangential direction. The surfaces of the test blocks were smooth but not sanded and the edges were free of loose fibers. Only those blocks free of visible defects and heartwood, as determined by color test described above, were used.

After the blocks were cut and selected, they were identified with India ink and brought to constant weight (approximately 12 per cent moisture) in a conditioning room maintained at 65 per cent relative humidity and 70° F. with constant air circulation and provision for removal of vapors of volatile solvents. Conditioned blocks were weighed individually to the nearest 0.01 g. (W_1).

Treatment: Four blocks were treated for testing and two for future studies on penetration for each concentration of preservative and for each treatment.

The blocks to be treated by dipping, cold soaking, or by hot and cold bath were tied into groups, each block separated from the other blocks in the group by two glass rods approximately 2 mm. in diameter.

The blocks in groups were treated by immersing for the required period of time in the case of dips and cold soaks. In those groups treated by hot and cold bath treatments, the groups were immersed in preservative at room temperature. The liquid was then heated to the desired temperature and immediately allowed to cool overnight. Blocks receiving brush or spray applications were treated individually.

An untreated group of blocks was used as a check for each series of treatments.

All products except the pentachlorophenol were applied undiluted. The pentachlorophenol was diluted 1:10 by volume in petroleum distillate before treating to make a 5 per cent by weight penta solution. Treatments were applied as dips and cold-soaks (in a logarithmic progression based on 22.5 seconds, each treatment being eight times the length of the previous); hot and cold baths and brush and spray coats. Low treating temperatures in the hot and cold bath were necessitated by the low flash and boiling points of the solvents present. Maximum temperatures reached were:

Zinc naphthenate	158° F.
Copper naphthenate	162° F.
Pentachlorophenol	170° F.
Rosin	130° F.

Analyses of the products: Laboratory analyses[2] of these products showed:

Zinc naphthenate: 3.75% Zn., equivalent to 37.5% Zinc naphthenate in petroleum distillate. Specific gravity 0.930 at 25/25° C.

Copper naphthenate: 1.81% Cu, equivalent to 18.1% Copper naphthenate in petroleum distillate. Specific gravity 0.825 at 25/25° C.

Pentachlorophenol: 26.44% total chlorine, equivalent to 39.7% pentachlorophenol as defined in Federal Specification TT–W–570, in fuel oil. Specific gravity 1.150 at 26° C. Distillation range:

100–190° C.	42%
190–270° C.	8%

with decomposition at 265° C.

Rosin: 27% Rosin, 5% Pine oil, 68% Petroleum distillate.

All of the treated and untreated blocks were reconditioned until they attained moisture equilibrium with the conditioning atmosphere, (about 12 per cent in blocks not treated with products containing hygroscopic solvents) and reweighed to the nearest 0.01 g. (W_2). The change in weight after treatment and reconditioning should be corrected for any significant change in moisture, indicated by changes in weight of the untreated blocks.

The residual weight (R) of the proprietary product and diluent, if any, in terms of grams per block was calculated for each block by subtracting the conditioned weight before treatment from the conditioned weight after treatment. $(R) = (W_2) - (W_1)$. Factors are provided in a footnote in Table 1 for those who wish to convert residuals in terms of pounds per square foot and pounds per cubic foot.

Each block was individually identified a second time by wrapping it with a piece of monel metal tape embossed with the same number inscribed on the block. This precaution was observed because the numbers inscribed in India ink on the untreated check blocks and those treated with unsatisfactory preservatives or given ineffective treatments were obliterated during exposure in the decay chambers.

Exposure: All blocks in a group were exposed by placing them adjacent to each other in a horizontal position in unsterilized sandy loam garden soil. The soil, fortified with about per cent (by volume) of pine sawdust, was contained in covered metal pans 8 in. deep, 6 ft. long, and 4 ft wide. Each pan, or decay chamber, was equipped with a soil heating cable thermostatically controlled to provide a temperature range of 75 to 80° F. About 3 liters of sawdust which had been sterilized and inoculated with *Lenzites trabea* (Madison 617) was applied to each pan (1 liter/8 sq. ft.) to inoculate the soil. (*Lentinus lepideus* (Madison 334) would be used for testing creosote preservatives.) The blocks were left undisturbed in the decay chambers for one year with their top edges barely below the soil surface. Moisture of the soil-sawdust mixture was maintained between 20 and 40 per cent on an oven-dry weight basis. At the end of the exposure period, the blocks were removed, washed, dried, reconditioned, examined for visible signs of decay, and again weighed to the nearest 0.01 g (W_3).

Evaluation of results: Two criteria may be used to rate the effectiveness of a given treatment or product, one visual and the other based on the percentage weight loss (or gain) in the treated blocks as compared to the untreated blocks. Both criteria are subject to certain errors as indicated by Duncan (5). Both methods have been employed in this preliminary report. Thus, the gain or loss in weight for each block, or the difference in weight between W_2 (after treatment) and W_3 (after exposure), was determined and the mean gain or loss for each treated group was expressed as a percentage of the mean weight loss for the group of untreated blocks.

The following system based upon visual characteristics of the blocks was employed:

[2] Analyses made by Chemistry Unit, Pesticide Regulation Section, Agricultural Research Service, U. S. Department of Agriculture.

Table 1.—PRELIMINARY EVALUATION OF AN ACCELERATED SOIL BURIAL TEST METHOD AS MEASURED BY THE EFFECTIVENESS OF FOUR COMMERCIAL WOOD PRESERVATIVES IN PETROLEUM DISTILLATE IN PREVENTING DECAY OF PONDEROSA AND SUGAR PINE SAPWOODS

Treatment	Zinc Naphthenate			Copper Naphthenate			Pentachlorophenol			Rosin		
	Average residual weight of product (R) gms.	Average change in weight after exposure compared to checks %	Average visual decay rating* No.	Average residual weight of product (R) gms.	Average change in weight after exposure compared to checks %	Average visual decay rating* No.	Average residual weight of product (R) gms.	Average change in weight after exposure compared to checks %	Average visual decay rating* No.	Average residual weight of product (R) gms.	Average change in weight after exposure compared to checks %	Average visual decay rating* No.
	Ponderosa Pine			Ponderosa Pine			Ponderosa Pine			Ponderosa Pine		
None (check)	0.00†	100.00‡	5.5	0.00	100.00	6.0	0.00	100.00	5.1	0.00	100.00	6.0
22.5 sec.	1.82	8.98	0.6	0.59	10.59	2.3	0.98	75.36	5.0	1.69	92.31	5.0
3 min.	2.06	20.34	1.0	0.81	12.84	2.5	1.09	82.25	4.9	1.55	145.29	6.5
24 min.	2.93	12.02	0.7	0.77	6.58	2.5	0.91	85.99	5.1	2.18	97.87	6.5
192 min. (0.13 days)	2.95	0.40	0.0	0.89	+3.37	1.6	2.72	70.89	5.0	3.16	108.62	6.0
536 min. (1.07 days)	5.18	10.04	0.0	1.00	+1.61	1.5	1.49	65.94	4.9	4.66	104.18	5.3
12288 min. (8.53 days)	7.18	1.59	0.0	1.71	+7.38	0.0	2.96	50.60	4.3	...	...	...
Hot and Cold Bath	27.96	39.76	0.0	3.44	7.38	0.0	8.24	73.31	2.8	5.66	98.34	5.5
1 Brush Coat	1.58	6.34	0.0	0.43	32.10	4.0	0.98	81.28	4.6	...	...	...
2 Brush Coats	2.45	4.76	0.1	0.61	6.10	3.0	0.92	68.96	6.0	2.53	118.70	5.5
1 Spray Coat	3.46	6.34	0.5	0.58	20.71	3.5	0.55	76.09	4.9	...	...	...
2 Spray Coats	2.18	7.40	0.5	0.60	13.00	3.0	0.85	98.19	4.9	4.51	88.99	5.5
	Sugar Pine			Sugar Pine			Sugar Pine			Sugar Pine		
None (check)	0.00	100.00	5.1	0.00	100.00	5.2	0.00	100.00	5.0	0.00	100.00	5.5
22.5 sec.	1.86	19.95	0.7	0.47	11.75	1.5	0.92	96.25	3.9	1.75	76.11	4.5
3 min.	2.40	13.47	0.4	0.52	17.35	1.1	0.90	112.10	4.8	1.59	90.97	5.5
24 min.	2.66	24.69	0.5	0.61	10.26	1.5	0.65	104.61	4.1	1.80	144.17	5.5
192 min. (0.13 days)	3.99	8.98	0.1	0.79	10.07	1.3	1.56	63.40	2.0	2.40	78.47	4.5
536 min. (1.07 days)	4.86	12.97	0.1	1.06	8.95	0.8	0.94	40.63	2.6	3.56	117.92	5.4
12288 min. (8.53 days)	6.81	20.95	0.0	1.76	8.58	0.0	2.33	60.23	2.1	...	...	...
Hot and Cold Bath	21.02	48.62	0.0	7.15	62.31	0.0	12.33	178.09	0.6	7.50	116.81	4.6
1 Brush Coat	...	...	...	...	...	...	...	...	...	1.57	85.56	5.0
2 Brush Coats	2.60	7.73	0.0	0.73	16.98	1.5	0.67	66.28	3.5	2.42	135.83	5.5
1 Spray Coat	...	...	...	...	...	...	...	...	...	3.47	116.67	5.0
2 Spray Coats	2.67	8.73	0.0	0.70	13.99	1.5	0.37	98.55	4.6	1.57	85.56	5.5

*Visual decay rating: 0=0.0% surface area of block involved; 1=20%; 2=40%; 3=60%; 4=80%; 5=100%; 6=20% volume of block missing due to decay; 7=40%; 8=60%; 9=80%; 10=100%.

†To convert to lbs./sq. ft. multiply by 0.01103, or to lbs./cu. ft. multiply by 0.72467.

‡Unless otherwise indicated, all changes in weight are negative, indicating weight loss.

RATING	VISIBLE CHARACTERISTICS
0- 0%	(none) of surface area of block involved with fungal attack.
1- 20%	surface area of block involved (staining, softening, sponginess or other visible signs of attack).
2- 40%	surface area involved.
3- 60%	surface area involved.
4- 80%	surface area involved.
5-100%	surface area involved.
6- 20%	volume of block rotted away.
7- 40%	volume of block rotted away.
8- 60%	volume of block rotted away.
9- 80%	volume of block rotted away.
10-100%	volume of block rotted away.

In practice it was found possible to differentiate blocks which fall between these 11 values and a decimal system was employed. For example: A block estimated as having 12 per cent of its surface area involved by fungal invasion would receive a 2.1 rating.

A rating based entirely on weight loss does not always indicate the true condition of the test blocks. Duncan (*loc. cit.*), Sedziack (15) and others have reported that part of all of the weight loss may be due to evaporation of the preservative material or solvents during the test period. Such "operational losses" commonly occur in treatments providing high retentions, such as hot and cold baths, where blocks may show considerable loss in weight due to exposure and still be perfectly sound. Another source of error occurs where hygroscopic solvents are used. The absorption of moisture results in an increase in block weight (W_3) even though the block obviously may be attacked by decay fungi.

It is assumed that any treatments to be worthy of the cost of materials and labor should at least double the service life of treated wood when compared to untreated checks. In these tests an individual treatment was evaluated by the criteria which indicated the greater effectiveness. Thus, in the case of high operational losses, where the average per cent change in weight for a treatment as compared to untreated check was very high, but the visual rating indicated little or no decay, the latter alone should be used for evaluation. An example of this situation is shown in Table 1 for sugar pine treated with copper naphthenate by the hot and cold bath method.

The visual scale must be used in evaluating the condition of blocks which show positive weight changes expressed as a per cent of the weight of untreated check blocks, resulting from the use of hygroscopic solvents.

A treatment would be considered unsatisfactory: (a) where the average change in weight as compared to the untreated checks is greater than −50 per cent; or (b) where the visual scale rating indicates the presence of more than one-half of the decay found in the untreated checks.

Evaluation and Discussion

Table 1 presents a summary of results obtained with four proprietary wood preservative products used in a preliminary evaluation of the proposed test method.

General considerations: Although results obtained with this method are not necessarily equivalent to a measure of the expected life of posts or other wood under service conditions, they provide a measure of the efficacy of treatments or products. Superficial, non-pressure methods of treatment provide a protected layer around a core of unprotected wood. Once the protected layer of preservative-treated wood has been penetrated by the fungus mycelium, the rate of decay may be expected to approach that of untreated wood. Penetration of the protictive layer by fungi may be accelerated under service conditions by the presence of termites or other wood boring insects (if the product is not at the same time a good insecticide against these pests), or by checking under atmospheric conditions, providing modes of entrance for the mycelium. Tests are being conducted in an attempt to correlate the results obtained with this method with those of stake-farm test on 2- by 4-in. posts.

On the basis of the results so far obtained, it appears that the method can be substantially improved by: (a) the use of larger number of blocks per treatment and (b) the selection of test blocks for uniform density.

Because of the uncertainty of operational losses and the possibility of a given product containing hygroscopic solvents, it appears that a visual rating is the only satisfactory basis for evaluation. However, both ratings should be used until the method has been thoroughly tested. Improvement may be made in the proposed visual scale to better differentiate surface signs of attack from obvious loss of volume due to decay. The surface signs of fungal attack appear to be most im-

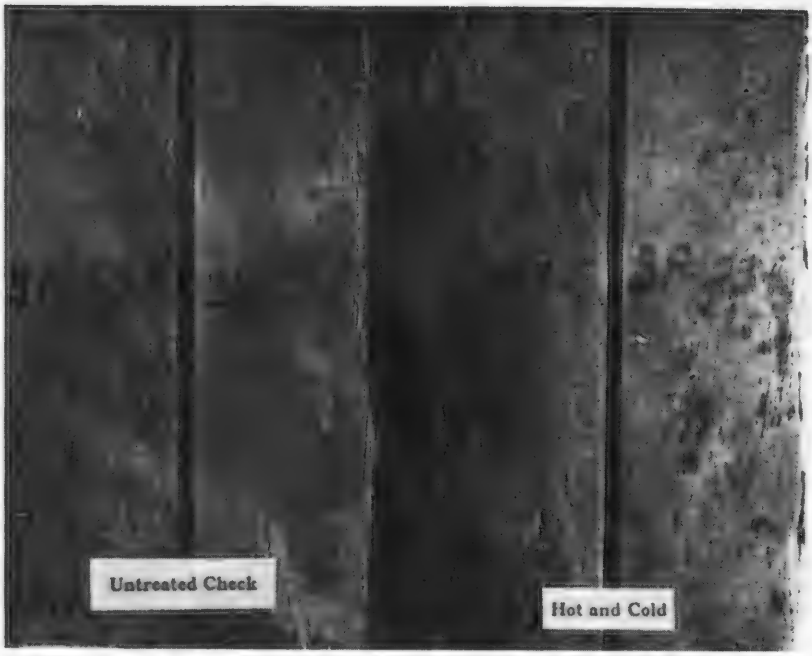

Fig. 1.—Comparison between representative blocks from untreated checks and hot and cold bath rosin preservative treated sugar pine, after exposure for one year in accelerated soil burial test.

portant in early evaluation of superficial treatments. Use of the American Wood-Preservers' Association log base scale (11) would place classes 1 through 5 of the proposed visual scale into log base scale 9, thereby masking these differences.

Ponderosa vs. sugar pine: A comparison of results obtained with each of the four products, representing eight separate experiments, presented in Table 1 shows that the residual weights of the products were slightly greater for ponderosa than for sugar pine, but that sugar pine had a tendency toward more uniform residual retention of a given product. Residual weights were least uniform for pentachlorophenol in both wood species.

Ponderosa pine generally lost more weight due to decay than did sugar pine, although either species could be used to secure essentially the same conclusions regarding the effectiveness of a treatment or product. Likewise, a given treatment generally showed a higher visual decay rating on ponderosa pine than on sugar pine.

Relative effectiveness of treatments: Hot and cold bath applications were found to be the most effective of any of the treatments used in these tests. Residual weights of products were generally from two to three times higher for hot and cold baths than for long term cold soaks (12288 min. or 8.53 days). The average per cent difference in weight for hot and cold bath treatments compared to checks indicated a relatively low order of effectiveness for this method of application for zinc and copper naphthenates and pentachlorophenol; however, the very low visual decay ratings (0.0 to 2.8) for these treatments compared to check ratings (5.1 to 6.0) showed them to be highly effective in preventing decay, and the weight loss must then be attributed to operational losses.

In the case of rosin preservative, the average percent change in weight after exposure compared to checks of 98.34 and the visual decay rating of 5.5 both indicated a very low order of effectiveness of that product for that method of application (see Fig. 1). In general, hot and cold baths are considered to be the most effective of the non-pressure methods for applying wood preservatives (10), the thoroughness of the treatment most nearly approaching that of the pressure processes.

Long time cold-soaking of 12288 min. (8.53 days) or 1536 min. (1.07 days) were the next best treatments, followed by 192 min. (0.13 days) cold-soaking. Little difference was found between dips and cold soaks of shorter duration.

Brush and spray coats were generally observed to be about as effective as cold-soaks of 24 to 192 min. Two brush or spray coats (applied within one hour of each other) were better than one coat in most of the cases tested.

Relative effectiveness of products: It will be readily apparent from a comparison of the results shown for the four products in Table 1 that the test method outlined above has distinguished between the effectiveness of the various products.

The zinc and copper naphthenate formulations have provided good protection against fungal decay under all treating conditions investigated. In the case of copper naphthenate, one brush or spray coat appears to provide the least protection. Pentachlorophenol was not as effective as zinc or copper naphthenate, only the hot and cold bath treatment being effective on ponderosa pine, and 192, 1536, 12288 min. cold-soaks and the hot and cold bath on sugar pine.

These results require further investigation, since 5 per cent pentachlorophenol (by weight) is usually considered to be an effective preservative for wood in contact with the soil when applied as a cold soak for 48 hours or longer (1, 8). However, Tippo et al (16) found that a 5 per cent pentachlorophenol solution failed to protect southern yellow pine exposed in soil at Morristown, N. J., and Emsweller et al (6) showed that pressure impregnation of ponderosa pine shooks to a retention of 5.6 lbs./cu. ft. with a mixture of 3 per cent pentachlorophenol and 2 per cent chloro-2-phenylphenol was not effective in preventing decay when the wood was used for greenhouse flats exposed to severe conditions in contact with the soil.

The rosin-pine oil preservative has been shown to be ineffective as a preservative against fungal decay for wood in contact with the soil.

Summary and Conclusions

A tentative, accelerated soil contact test method has been described for evaluating the effectiveness of proprietary wood preservatives in relation to provisions of the Federal Insecticide, Fungicide and Rodenticide Act of 1947. Results of preliminary tests, using four products containing different toxic ingredients, have shown that the method may be useful in evaluating different products and superficial, non-pressure methods of application as might be employed by the average householder or farmer for the protection of wood to be placed in contact with the soil. It would not be considered a desirable test for the evaluation of products intended to be applied to door and window frames or wood not in soil contact.

One product each, containing either zinc naphthenate or copper naphthenate as the active ingredient, have been shown to afford adequate protection to wood in contact with the soil when applied by any of the treatments investigated.

One product containing pentachlorophenol has been shown to be ineffective when applied by dip, short

time cold-soak, or by brush or spray treatments. Long time cold soaks and a hot and cold bath, employing relatively low maximum temperatures, were found to be effective.

One product containing rosin, pine oil, and petroleum distillate was shown to be ineffective when applied by any of the methods tested.

Ponderosa pine (*P. ponderosa*) and sugar pine (*P. lambertiana*) sapwood have both been used successfully in this method, but it is concluded that for the purpose of comparison of different products one species should be used. Ponderosa pine is suggested as the more acceptable, due to its higher rate of decay.

Two criteria of evaluation of the performance of a product or treatment have been suggested, one visual and the other based on the mean weight loss of the treated blocks compared to that of the untreated checks, expressed in percentage.

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Cost and Marketing of Plugged Lumber[1]

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Estimates costs of plugging knots by two different machines and discusses advantages and disadvantages of each. Suggestions are made for effective use of either patching method. A market survey of lumber dealers and other commercial outlets indicated that there are markets for plugged lumber if the product is well-manufactured.

THE ADVENT OF SPECIALIZED MACHINERY designed for boring out and plugging defects in lumber has revived interest in the possibilities of knot plugging. The idea is not new or untried as box factories, for one example, attempted knot plugging years ago.

In 1936 the Western Pine Association's Research Laboratory spent some time in calculating the cost and amount of lumber suitable for plugging. The small diffeernce in price between lumber grades and the lack of suitable equipment were serious disadvantages which resulted in discontinuation of the study. However, since that time the price differential between grades has increased and better machinery has become available.

Two important factors that need to be considered before producing plugged lumber are: can the boards be plugged economically and can the product be successfully marketed? To be plugged economically means the patched board must be sold for its original market price plus plugging costs plus a reasonable profit. This first part of the paper will be concerned with estimating the costs entailed in lumber plugging.

Costs of Lumber Plugging

When considering the grades of lumber to be processed, the price spread between No. 3 Common and No. 2 Common and between D Select and C Select indicated profitable fields in which to operate. The price differential between No. 4 Common and No. 2 Common was not considered because of the limited size of defects the machines could remove.

The preliminary work on plugging costs that had been done at the laboratory some years back was taken as the starting basis for the current work. At that time a 12 inch by 12 foot board was considered an average piece and the same size was used in this study.

In the first cost analysis, two defects per board were considered to be plugged while in the second analysis, six defects per board were considered to be plugged. The two machines were chosen because they represent two extremes in design and operation. One is almost entirely an automatic operation with a correspondingly high investment while the other is a hand operated unit with a low investment.

The cost estimates included in this paper were computed after making time studies using both machines. Included in the time study was the time

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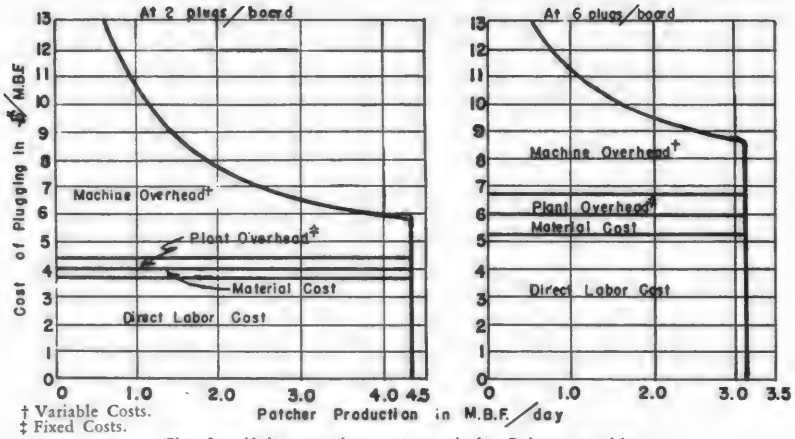


† Variable Costs.
‡ Fixed Costs.

Fig. 1.—Unit operating cost graph for Raiman machine.

needed to pick up, inspect, plug, and dispose of each board. The estimated machine capacity was calculated after allowing ample non-productive time for moving loads in and out, rest periods, glue mixing, and clean-up.

Material costs for the stock from which the plugs were cut was placed at $10 per M lineal feet, a figure given by a member mill. No charges were made for glue or power consumption as these costs were assumed to be low enough to exert practically no influence on final costs.

Total operating cost graphs were prepared and resolved into unit operating cost graphs which are shown in Figs. 1 and 2. From these, each individual mill can determine the cost of plugging a given amount of stock by either of two methods and using a different number of plugs.

These graphs show that a Raimann machine should be able to plug lumber,, with 6 plugs per board, for a cost of $8.65 per M b.f. This amounts to slightly less than 3 cents per plug.

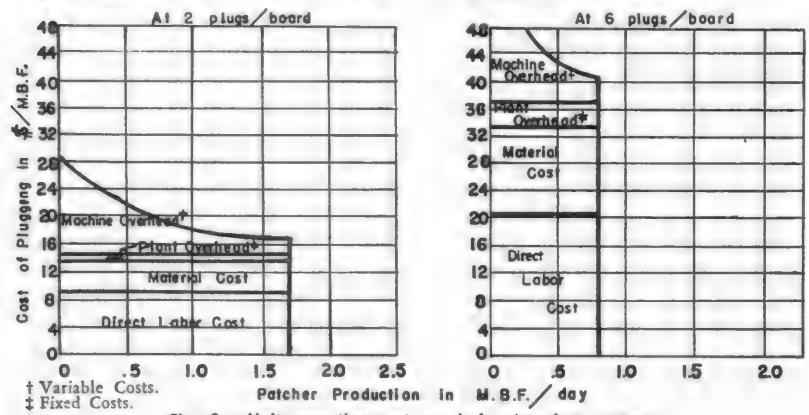
The graph showing the unit or MBF operating costs for the Raimann Automatic Knot Boring and Plugging Machine assumes as the capital investment:

1 Raimann machine	$5900.00
1 scissors lift	740.00
Estimated cost of roll cases	200.00
Total Investment	$6840.00

The investment is to be retired in five years. A scissors lift was included in this investment because the major time consuming element is handling the boards from the load to the machine. Only one man is needed for the machine and all he has to do is place the defect under the bit and step on a pedal.

The piece is firmly held in position by a clamping device while the bit bores out the defect and then automatically returns. A blower supplies air to remove the chips, then a new type glue injector sprays glue to the sides and bottom of the hole. The carriage moves to the side while a plug is cut from a strip in the magazine and driven into the hole. The entire operation takes about 4 seconds per plug. Roll cases are necessary for ease of moving the board from one defect to another.

The second method used, the American Portable Patching System, requires more labor to plug lumber than the automatic machine but correspondingly has a much lower investment cost. The complete system consists of a patch cutter to manufacture the plugs and a defect cutter to remove the knots, etc. However, patches already manufactured, either from customer or American material, can be purchased thus eliminating the need for a patch cutter.



† Variable Costs.
‡ Fixed Costs.

Fig. 2.—Unit operating cost graph for American system.

Since the patch cutter costs more than the defect cutter and it was desired to keep investment costs at a minimum in this operation, it is assumed all patches will be purchased ready-made from customer material. Since the major time consuming element is routing out the defects and placing the plugs, a scissors lift was omitted from the operation. Capital investment then would be:

1 American Lumber Defect Cutter	$450.00
Estimated cost of roll cases	200.00
Total Investment	$650.00

An investment such as this should be retired in 1 year. In this operation a man is required to place a portable router over the defect, machine it out, select a plug, coat it with glue, place it in the hole, then drive it in snug with a mallet. As can be expected, this sequence of movements take considerably longer than with an automatic machine.

The estimated capacity figure was calculated by the same procedure as for the automatic machine. Material costs were also assumed to be $10 per M lineal feet. The reason why material costs on the charts show so much difference is that a great deal more labor is expended in plug manufacture in the American system than in the other.

These figures indicate that the American Portable Patching System should be able to plug lumber with 6 plugs per board for a cost of $40.38 per M.b.f.

From the above it would seem that the hand operation would only be suitable for small operations where a large investment was not warranted. If a substantial amount of lumber suitable for plugging is available every day, then a more mechanized operation should be considered.

Although Figs. 1 and 2 show the cost of plugging various amounts of lumber by the two methods, other factors cannot be shown graphically. Some operators may feel the risk involved in marketing plugged lumber warrants only a small investment that can be quickly written off. The Raimann machine is limited to round plugs of a maximum 1–9/16 inches diameter. We have been informed that a machine with a 3-inch diameter bit will soon be available. The American patching machine makes an oblong-ovate plug from ¾" to 1–½" wide by 3–¾" to 5" long. It is felt by some that the oblong-ovate patch presents a more pleasing appearance than a round patch.

While the labor costs are considerably higher in the portable system, the operator has the opportunity to choose a plug that most nearly resembles the board in grain and color characteris-

tics. From this it would appear that both systems have certain advantages and disadvantages.

In order to effectively use the patching methods the following suggestions are made:

a. Stock should be plugged rough dry then surfaced.
b. Stock should be selected boards that can be up-graded with a minimum of plugs are preferred.
c. Limit patching to one plug per defect; multiple plugs have a displeasing appearance.
d. Color of plugs and boards should match as close as possible, i.e., heart plugs in heart boards and sap plugs in sap boards.
e. For best appearance and use, grain of plugs and boards should match; flat grain plugs in flat grain boards, etc.

Also, if the stock from which the plugs are made is considerably dryer than the atmosphere likely to be encountered in use, a tighter plug will result.

Market Acceptance

In order to supplement the preceding estimated cost of plugging, it was felt a market survey should be made to determine if plugged lumber could be successfully marketed. Accordingly, two sample boards each containing a round and an oblong plug were sent to the Promotion Department's field men. A list of questions was also sent along. The number of contacts made and the area covered should give a reasonably accurate picture of the trade reaction to plugged lumber.

Each field man was asked to show the samples of plugged lumber to the dealers, salesmen, cabinet makers, etc., he called on and to ask them the following questions: Would they accept plugged lumber; what price would they be willing to pay for it; preference for either of the plug shapes; how many plugs in a 16-foot board would be acceptable; and should the plugged stock be shipped mixed or separated? The samples were 1" x 8" x 4' and were meant to represent a D Select type that had one or more black knots, which although replaced on the face by a plug, were visible on the back of the board.

The results of the first question are expressed as a per cent of the more than 300 businesses contacted. While the overall outlook for plugged lumber, as shown by Fig. 4, seems favorable, many of the answers were qualified. Some dealers wanted a waterproof glue, many wanted assurance that a consistently well manufactured product would be available, and some offered to take the stock only at a price lower than its original unplugged market value. The majority, though, were willing to pay a price that assured the manufacturer a reasonable profit.

While Fig. 4 shows the degree of acceptance of all those contacted, a further breakdown, indicated by Fig. 5, shows the per cent of acceptance of each business group.

When asked what price they would be willing to pay, not all those that indicated they would accept the stock would set a price on it. Some felt it would be up to the mills to price it or that the mill and dealer would work out the price. However, 95 per cent of those asked the question did give an answer. An indication of the price that these dealers would pay is illustrated by Fig. 6. It must be clarified, though, that between C and D means from just above D to almost a C price, and as can be expected, more answers were in the lower end of the range than the upper. Generally speaking, however, the answers indicated that a price favorable to both parties could be established.

Fig. 7 shows the total of all dealers reduced to individual business groups. It shows by type of business, the various prices, with the per cent of those willing to pay that price.

The shape of the plug used, the round one vs. the long one, seemed of least importance. Out of all types of business questioned, only 36 per cent expressed any preference for a particular plug. Up until the survey, it had been felt that the oblong patch was somewhat more pleasing to the eye than the round type. Somewhat surprisingly, 71 per cent of those who expressed preference favored the round plug and only 29 per cent the oblong one.

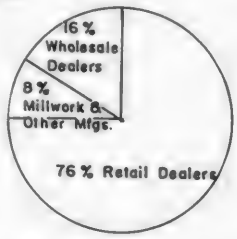


Fig. 3.—Distribution of total contacts by business groups.

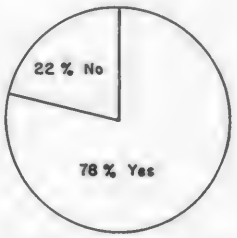


Fig. 4.—Distribution of total contacts by acceptance of plugged lumber.

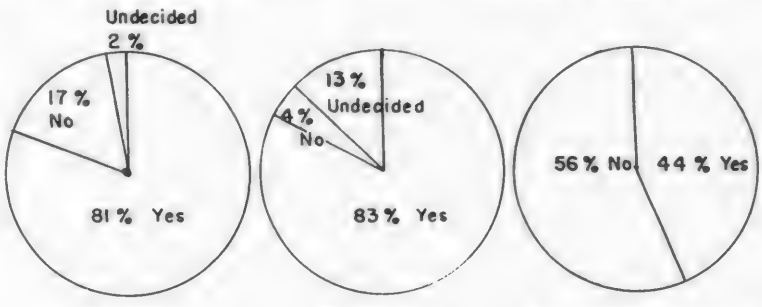


Fig. 5.—Distribution of acceptance by business groups.

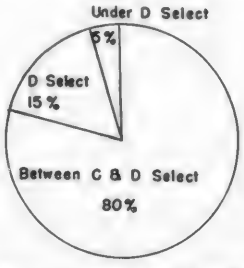


Fig. 6.—Distribution of total acceptance by suggested value.

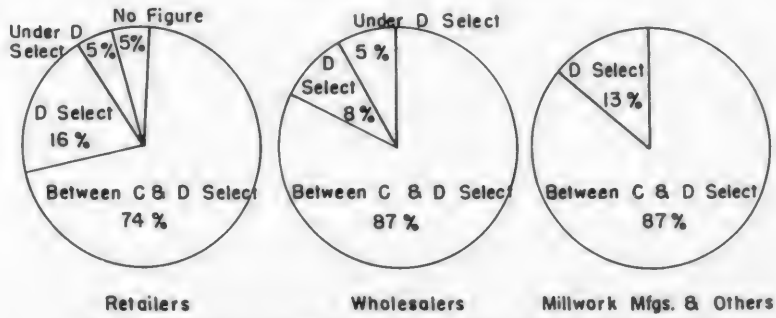


Fig. 7.—Distribution of acceptance of suggested value by various groups.

When asked how many plugs in a 16-foot board would be acceptable only 73 per cent were definite about the number. Many of these would not commit themselves to a set figure but indicated a range as 4 to 6, 7 to 8, etc. Other figures expressed with the number of their occurrences in the survey are presented in Fig. 8. A combination of the figures would show that 89 per cent of those questioned felt that up to 6 plugs should be maximum, and only 11 per cent would accept 7 or more plugs per board.

To the question, should plugged lumber be shipped separately or mixed, 96 per cent of the total who would accept the stock, answered as follows: 67 per cent would prefer the stock separated and 33 per cent would accept it mixed.

Conclusions

The result of this survey indicate that plugged lumber would meet with favorable reaction from the dealers. There are cloudy spots in this bright future, though. The ultimate decision on plugged lumber's acceptability will be made by consumers, and of course,

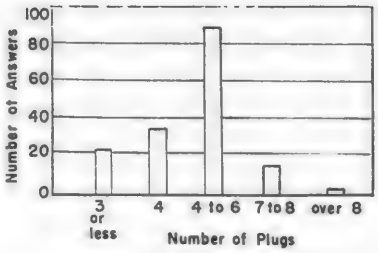


Fig. 8.—Acceptable number of plugs in a 16-foot board.

they were not reached by this survey. Two dealers who are now handling plugged lumber commented that they were experiencing difficulty in moving the stock. On the other hand, one dealer said he had D Select in stock for 3 years.

Opinions concerning the stock varied by the areas covered. The greatest resistance to plugged material was met in the New York–New England region. Apparently finger-jointed stock had met resistance in this area and many of the dealers were skeptical about any type of glued stock. The field men in this area reported that those dealers that would accept the stock would do so only if waterproof glue was used.

Throughout the states of Iowa and Missouri, the field man reported that all those he talked to definitely preferred the plug rather than a black knot. He stated most of the wholesalers thought plugged lumber a good idea and that they would have no trouble selling it.

In the Mid-Atlantic area, the idea of a plugged "D" was in general quite enthusiastically received by wholesalers and retailers who sell the building trade. Yards that sell mainly to industrial customers were about evenly divided in their reaction to the stock.

The lake States and the Ohio-Indiana region were generally receptive to the idea, also. In California the field man reported that while the dealers said they would accept it, he doubted if many would have actually bought any had he been taking orders.

From all indications there is a place for plugged lumber in the trade and all that is required for successful marketing is diligent selling plus a well-manufactured product.

The Future of Rubber-Tired Tractors in Logging[1]

W. E. McCRAW

Logging Representative, Sales Development Division, Caterpillar Tractor Co., Peoria, Ill.

Rubber-tired tractors now being offered by manufacturers should be considered strictly experimental designs, with a considerable range in horsepower and weight. Test experience has shown that the use of rubber-tired tractors in conjunction with conventional track-type tractors will have a tremendous influence on future logging methods. They can be used to yard out much greater distances, thus reducing the necessity of building truck roads to the stump.

ONE OF THE MOST SIGNIFICANT developments in logging equipment today is being done by tractor manufacturers in the design and manufacture of rubber-tired tractors for logging. While most units produced as yet could be considered as experimental, there is no doubt—from results to date—that rubber-tired tractors are here to stay, and that the future of rubber-tired tractors in logging will be tremendous.

[1] Presented at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: W. E. McGraw is a graduate of the University of Toronto. He joined Anglo–Newfoundland Development Co. in 1928 as research forester, successively became chief forester, logging engineer, and assistant woods manager. McCraw has held his present position since 1948.

The present designs of rubber-tired tractors should be considered to be strictly experimental—they are mainly conversions of track-type tractors to rubber, slight changeovers from conventional truck design, or enlarged versions of the farm tractor type of units. Some are adaptations of earth-moving rubber-tired tractors and track-type tractors that have proven themselves on these jobs and are now being adapted and tested on logging applications.

The performance of these prototypes, however, has in the main surpassed the fondest hopes of their manufacturers so much that their future use will be greatly expanded—to complement conventional track-type tractors now being used in logging operations in that unending struggle against rising logging costs. This is the reason for their being and if they can assist in holding down rising costs, then their future is assured both in pulpwood and sawtimber operations.

Performance Test Results

Predictions of the future of rubber-tired tractors in logging should be based on experiences of the past few years in testing experimental units.

Our firm's tests are based to date on four horsepower classes; the 300 HP DW20, 4 x 4, the DW15 186 HP, the 110 HP rubber-tired conversion of the D6, and the 38 HP rubber-tired conversion of the D2. These covered a wide range of tractor sizes and a wide range of logging chances from the large timber on the West Coast to the small pulp-wood in the Southeast, including pulpwood and sawtimber logging in the Lake States and Northeast. (It should be noted that rubber-tired conversions of the D2, D4, and

D6 are made by our dealers. The conversions are not production units of the company.)

Generally, the results were good. Their performance often exceeded expectations and the designs were acceptable to the industry—being simple, rugged, versatile, easy to maintain, and without new and complicated mechanisms or untested new devices and attachments.

While improvements in these products will be unending, it is believed that production designs of these rubber-tired tractors for the next few years will be substantially the same as the experimental units. This thinking may be conservative but it would be unwise to introduce at the same time new machines requiring new operating techniques and job layouts. It is better to introduce them gradually one at a time. Then the industry does not become confused with the whole new approach.

Experiences to date indicate that rubber-tired tractors will have a great influence on future logging methods. Their great potential has not always been appreciated nor achieved in tests as they have been used to simply replace track-type tractors.

New Logging Tool

Actually, their greatest potential lies in their ability to replace, to some extent, the logging truck. It is a matter of working out better logging methods that will put them to their most efficient use. Rubber-tired tractors are a new tool in the logger's hands and as such they need new techniques to minimize their shortcomings and to fully utilize their virtues.

Testing experiences have given some ideas of their shortcomings:

1. They do not have the ground contact area of comparatively same size track-type tractors and consequently:
   a. Cannot do heavy bulldozing effectively.
   b. Do not have the flotation in soft ground of track-type tractors.
   c. Do not have the gradeability of track-type tractors.
   d. Are more subject to limitations of applications by ground conditions than track-type tractors.
2. They are not as efficient as track-type tractors in working among stumps in prebunching logs. The height of the fairlead of integrally mounted arches has a tendency to tip back the unit in winching in heavy log loads.
3. Large tires are expensive and tire wear can be excessive if the machines are not operated wisely.

Advantages

On the other hand, rubber-tired tractors have some virtues:

1. *Speed*—Ability to travel over rough secondary roads at fairly high speeds at least double track-type tractor speeds.
2. *Yarding ability*—They are able to yard out log loads almost equal to track-type tractors of the same horsepower class.
3. *Maintenance*—The large, low-pressure tires reduce shock and impacts to the tractor. There are also fewer wearing parts and these two factors should reduce maintenance costs.
4. *Operator comfort*—Again, the large tires cushion the machine and operators report much less fatigue at the end of a working day.
5. *Clearance*—Rubber-tired tractors have much higher clearances than comparative track-type tractors—giving them better travel ability in mud, snow, and over stumps and brush.
6. *Versatility*—The fact that they are rubber tired permits them to travel on public roads on which track-type tractors are prohibited. Therefore, they can travel on their own and can do many other jobs—snow plowing, shoulder grading, truck assist on heavy grades, and other miscellaneous jobs. Other applications have been carried out in forest management work—such as fire line plowing and tree planter hauling. These are jobs that the machines do well.

Summing up the pros and cons of rubber-tired tractors, it may be concluded that their advantages are speed, good loadability, and less maintenance. On the other hand, it is important to learn the limitations of the units so as to not ask too much of them and thus reduce their productiveness to uneconomic levels.

From field tests, the following production data has been noted:

(1) DW20, 4 x 4—2 miles round trip, 100 M/8 hr. day—Vancouver Island.
(2) DW15—12 miles round trip, 27 M/8 hr. day—British Columbia.
(3) Rubber-tired conversion of the D6—1 mile round trip, 70 M/8 hr. day—Maine.
(4) DW20—1–1.5 mile round trip, 72 M/8 hr. day—Idaho. No prebunch—1–1.5 mile round trip, 42 M/8 hr. day—Idaho.

Note the difference in production when the DW20 did its own bunching, a loss of 30 M feet per day. This points up the fact that rubber-tired tractors require prebunched loads for best production—that they are better used as a semi-truck than as a bunching tractor.

In Maine in yarding birch tree lengths in an integrated pulpwood-sawlog operation, we were going past five truck road locations in skidding. When it is considered that these bulldozed winter truck roads cost about one dollar per cord, the potential savings in yarding timber can be readily realized.

For example, a proposed method in yarding a logging chance would be to build a main truck road into a chance and then to bulldoze a system of yarding roads, instead of truck roads, into the remainder of the area. Then, the track-type tractors would prebunch log loads for the rubber-tired tractors. In this way, the best operating features of the three units—track-type tractors, rubber-tired tractors, and log hauling trucks would be used correctly and at their lowest operating cost.

In many forest regions, virgin timber is still being cut for various forest products. The location of this timber is becoming more remote, higher up in the mountains—requiring more road building per unit of timber removed than previously from the lower slopes and better sites. Heavier loads are being carried on larger log trucks necessitating better truck roads. The cost of truck roads has become an important item in logging costs.

The use of rubber-tired tractors, therefore, can have a decided impact on the cost of delivering timber from the stump to the mill by reducing the amount of truck roads required. Second-class rubber-tired tractor roads can be built for one-quarter to one-third truck road costs.

This, then, is the future of rubber-tired tractors in logging—they can be used to swing logs from prebunched areas to the main truck road over varying distances up to several miles. It is a big future—our forest products industries are continually expanding—and improved designs of these tractors in the years to come will have a tremendous effect on logging methods and costs.

Discussion

H. T. Larmore[2] (Allis-Chalmers Manufacturing Co.): Mr. McGraw has ably echoed the general feeling of the tractor industry that rubber-tired tractors of the proper sizes and type can, if properly applied to many logging operations, contribute to that ever more popular goal of reduction of cost in moving the wood from the stump to the mill or processing plant. We also firmly agree that there must be a parallel evolution of both ma-

[2] Mr. Larmore was scheduled to present these prepared comments following presentation of the paper but was unable to attend the meeting. His comments were read by R. G. Richards, Construction Machinery Sales Manager, Allis-Chalmers Manufacturing Co., Richmond, Va.

chinery and job methods in order to effect this cost reduction.

Perhaps if we look at a relatively recent evolution of machinery and job methods in the dirt-moving industry we can point out some of the factors involved. Prior to World War II, most of the dirt for construction jobs in this country was moved with crawler tractors and tractor-drawn scrapers, and on long haul jobs with trucks loaded by power shovels. At the conclusion of World War II, a number of manufacturers developed rubber-tired motor scrapers; a general trend was to move dirt with rubber-tired motor scrapers irregardless of haul distances or other conditions which would normally dictate the type of equipment to be used on the job. In some cases the pendulum swung much too far in the direction of the rubber-tired motor scraper for many contractors. The motor scraper went through many stages of evolution before arriving at its present form, but during this time we also witnessed a like number of changes in job methods.

Today you will find the general contractor using a diversified fleet generally broken down into three classifications which he uses wisely, intelligently, and efficiently as a result of the several years of experience now available to him with the rubber-tired motor scraper.

To help illustrate the parallel between the dirt moving evolution through motor scrapers, and the possible rubber-tired tractor evolution for the logger, the three basic types of earth-moving equipment on a general contractor's diversified fleet would include:

1. Crawler tractors and scrapers for the short haul.
2. Motor scrapers for the medium haul.
3. Trucks with power shovels or other loading devices for the long haul.

We can visualize a parallel grouping of equipment for the average logger with crawler tractors doing the short haul work, bunching, and of course, doing the bulk of the road building and pioneer work. The second class or group of equipment would in all probability consist of the rubber-tired tractors with suitable tools to take over the medium haul operations which might be directly to the mill, but more generally to truck landings, waterways, or railroad sidings. The third class or type of equipment would be trucks or other types of high speed hauling equipment for the long haul operation.

During this development period of the rubber-tired tractors for the loggers, we must have an accompanying or parallel development of associated tools. The utilization of somewhat higher travel speeds obtainable from the rubber-tired tractor over the crawler tractor may necessitate major changes in familiar tools such as logging arches and sleighs. It could very possibly lead to the development of combination tools that could be used in packaging and loading operations. Tools such as these have a tendency to become somewhat specialized to fit the particular type of logging operation carried on in a particular area, but the past history of the tractor industry would tend to indicate that the prime mover or major product involved (in this case the rubber-tired tractor) must finally conform to a design which can be generally used throughout the logging industry, regardless of geographic location and terrain. We believe this is worthy of major consideration by the logging industry. A tendency on the part of the users to insist on and demand specialized tractors for every possible kind of logging operation will have a decidedly adverse effect on the manufacturing costs and ultimate selling price through the reduction in volume of each type.

It goes without saying that each tractor manufacturer, the tractor industry as a whole, and the logger all benefit by the development of cost cutting equipment. Probably every major tractor manufacturer now has rubber-tired tractors of some kind and type currently under tests and evaluation for logging operations.

In closing, we can heartily agree with Mr. McCraw that rubber-tired tractors in the years to come will, if intelligently applied to many logging jobs, contribute in no small way to the conservation and full utilization of wood products and also contribute by lowering merchandising costs for the wood products industry.

C. S. Walters (University of Illinois): Do you think these units will be difficult to maintain under field conditions? Do you think the companies will have to have special maintenance crews to take care of these tractors?

Mr. McCraw: In testing our DW 20 for 13 months in the woods, repairs were very little. One tire was punctured when it was run over a sharp rock and had to be replaced. There was little tire wear, so I do not think they will be difficult to maintain. A lot of credit is due the tire manufacturers for developing a tire for these tractors.

R. H. Matson (American Cyanamid Co.): Are these round trips to the landing?

Mr. McCraw: These are round trips from the log bunching areas to the truck landings.

Mr. Matson: What sort of equipment was behind the tractors?

Mr. McCraw: They were used with rubber-tired arches in some tests. The DW 20 and DW 15 had integrally mounted arches. There was no appreciable wear on the logs, even on long hauls.

W. W. King (Tennessee Valley Authority): Do you have any comparative data to show the limits of per cent slope on log loads between rubber-tired and lug tractors?

Mr. McCraw: We found that rubber-tired tractors did not have the grade ability of track-type tractors. The steepest grade rubber tired tractors could negotiate was about 40 per cent whereas track-type tractors can climb a 65 per cent grade.

How to Prevent Fungus Damage to Wood Structures[1]

ARTHUR F. VERRALL

Pathologist, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Gulfport, Miss.

The general principles for protecting wood from decay are discussed. Decay can be controlled by use of well-manufactured and properly handled lumber, with construction features to minimize moisture accumulations. For specific uses of high decay hazard, a naturally decay-resistant wood or one with proper preservative treatment is necessary.

WOOD IS ONE OF OUR MOST ADAPTABLE building materials. Like any other material, however, it is subject to deterioration under certain conditions. This susceptibility to decay should be construed not as meaning that wood is a poor building material but merely as a warning to use it properly. The general principles for protecting wood from decay will be discussed in this paper. Prevention is relatively simple and need add little to the original cost of building. In fact, if maintenance costs are also considered, decay-prevention measures are money-savers.

Prevention is the combined responsibility of the lumber industry (manufacturers and handlers), the construction industry (architect and builder), and the owner. Improper procedures anywhere along the line wood travels from the tree to the finished building can contribute to a decay hazard. Most of the problems of decay can be met either by moisture control or, when this isn't feasible, by the use of wood that has been treated or is naturally resistant to decay. Dry wood (kept below 20 per cent moisture content) won't decay.

Green or Partially-Seasoned Lumber

Sometime during air seasoning green lumber has an optimum moisture content for the development of decay, stain, and mold. Therefore, the first step in decay prevention lies in good manufacturing procedures. Details of such procedure are available in numerous publications. It will suffice to point out here that lumber cut from fresh logs, promptly dipped in a stain-control solution, and properly air seasoned or promptly kiln-dried, will reach the market relatively free from fungus infections.

Mold and stain develop first in improperly handled green lumber. They have little effect on mechanical properties but harm the appearance and can later cause paint discolorations. What is more serious, fungi increase moisture permeability of wood so that it is more easily wetted to a moisture content suitable for decay. Infected wood should never be used in siding or other places where some amount of rain wetting is inevitable.

Stain and mold also act as a warning that incipient decay may be present. Decay fungi grow under the same conditions as do molds and stain, only more slowly. After normal air-seasoning periods, decay infections are seldom obvious in stained and molded lumber. Nevertheless, they may be present. Many decayers are not killed by air drying and can survive for years. They will become active when suitable moisture conditions prevail. Thus poorly handled lumber, even when dry, entails certain risks because it is not only more absorbent but also is likely to harbor an established decay fungus ready for action on rewetting.

These incipient infections can also occur in well seasoned and manufactured lumber if it is stored on the ground or subject to rainwetting. The use of sound, bright, dry lumber, particularly for exterior woodwork, is a very important initial step in decay control. It is for this reason that siding and exterior millwork preferably should be bright and kiln-dried.

Occasionally decay occurs when green or rain-wetted lumber is installed in such a way that it cannot quickly dry after construction is completed. Ordinarily lumber for building construction should be dry when used, but any moist or wet wood that must be used should not be tightly enclosed until it has dried. A certain amount of rain wetting of framing and sheathing during construction isn't serious unless the wood is stained or molded. Bright wood is quite resistant to deep penetration of water; in normal showers only the surface wets. Badly infected wood can absorb dangerous amounts of rainwater.

Soil Moisture

The soil is the main reservoir for the water which allows decay in sills and other substructure members. This includes decay by the relatively rare but destructive water-conducting rotters. Soil moisture can also wet wood by direct contact, by capillary rise through concrete and masonry, or by condensation.

In permanent structures, untreated floor joists ordinarily should have a minimum clearance of 18 inches over basementless space. Some concessions must be made for sills and girders, but if the clearance is less than 12 inches decay-resistant or treated wood is desirable. A metal termite shield is an effective means of preventing capillary rise through foundations. If it is necessary to have any wood in contact with the soil, the wood should be impregnated with a suitable preservative. Siding, sheathing, and similar material should never be closer than 8 inches to the soil unless treated.

One of the most common points of soil contact or near contact has been the sill back of dirt-filled porches and stoops. So much decay and termite trouble has arisen at this point that dirt fills are not recommended unless the top of the porch slab is below the sill or the porch or step is separated from the main structure by at least 2 inches. Self-supporting slabs are definitely preferable for porches. All forming boards should be removed after concrete has set.

The capillary movement of water through concrete can be an extremely important contributor to decay in slab-on-ground buildings and in basements. In basements, actual hydrostatic pressure, as well as capillarity, can be involved. A dry basement requires combinations of the more water-resistant concrete mixes, good drainage, and waterproof membranes. The drier the

[1] Presented at Session III, Wood Preservation, FPRS Tenth National Meeting, June 6-7, 1956, in Asheville, N. C.

The Author: A. F. Verrall holds M.S. and Ph.D. degrees from the University of Minnesota. He is the author of numerous papers on the fungus deterioration of wood and its control.

basement the less additional protection will be needed for any wood used therein. In general it is best to have all wood in basements, i.e., stair carriages, columns, and wall plates, resting on raised concrete footings capped with metal or other flashing material. The other alternative is the use of treated wood.

The slab-on-ground construction raises many problems in decay control through moisture regulation. Proper protection for a house requires, except in the driest regions, the use of a sub-slab base of non-capillary material at least 4 inches thick, a water-proof membrane either below or above the slab, and the elevation of the slab top at least 12 inches above grade. For garages and industrial buildings less stringent measures may be acceptable depending on how much moisture can be tolerated.

Even in a waterproofed slab, wall plates and nailing strips should be of treated wood. If a sub-slab moisture-proof membrane is used, some water leakage may occur at the slab edge. Flashing the peripheral wall plates is desirable. Decay in slab-on-ground construction can be severe and costly to remedy. For this reason the most stringent preventive measures are recommended.

Vapor from soil water can lead to serious decay of substructure wood in basementless houses. Vapor cannot directly raise the moisture content of wood into the danger zone but if the basementless space is wet and unventilated, condensation can occur on sills and joist ends during cold weather. Surprisingly little ventilation is needed to prevent this condensation. Certainly any of the commonly recommended formulae (such as properly located side vents = 1/160 of the ground area) will prevent or cure substructure condensation. However, condensation is primarily a cold-weather phenomenon and when ventilation is used as a sole control, it is necessary to insulate the floors and water pipes.

A cover over the soil will accomplish the same purpose as ventilation and permit complete closing of vents in cold weather. Any durable vapor-barrier material will serve as a soil cover and will prevent evaporation of soil water into the crawl-space atmosphere. Fifty-five pound roll-roofing has proved effective and durable. Undoubtedly other materials will eventually be proved satisfactory soil covers.

A small amount of ventilation will prevent serious condensation in the substructure but will not always prevent condensation in walls or flat roofs if effective fire stops are omitted and crawl-space air can get into the wall void. This has been particularly bad with brick veneer types. Wall and attic condensation from other causes will be mentioned later.

Rain Water

Rain water is the main source of the moisture which allows decay in exterior woodwork of buildings such as roof edges, steps and porches, siding, and exterior trim. The best protection for these items is to design the structure so that wetting is restricted and any wood that should become wet is quickly dried. Wood installed in areas of high decay hazard should be naturally decay-resistant or treated with water-repellent preservatives.

It is extremely difficult to keep all water out of exterior woodwork in regions of moderate to heavy rainfall. Even when this water leakage does not lead to decay, it can contribute to paint failures and warping or other wood troubles associated with moisture changes. Tight joints and caulking are not the answers. If appreciable water flows over the wood surface, it will get in back of the wood regardless of how well the carpentering is done. The following are the main points for protection against decay resulting from rain seepage:

(1) Good roof overhang will do more than any other single item in keeping rain water out of the walls. Overhang is needed on gable ends as well as at the eaves. A 1-story building with a hipped roof having 24 to 30 inches of overhang is ideally suited to the warmer and wetter areas of the country. Eave gutters are desirable if roof overhang is less than 18 inches. In drier areas considerably less roof overhang may be acceptable, but for most of the country a good roof overhang is advantageous.

(2) Metal flashing is needed to direct water past openings in and projections from the wall, between porch slabs and woodwork, at chimneys, and at roof edges. At roof edges, flashing should form a drip edge free from the wood.

(3) Water-repellent preservatives are important means of keeping exterior woodwork dry. Siding, sash, screens, trim, and roof edges are some points most benefited. Fortunately, good water repellency can be attained by brush, spray, and dip treatments. However, the effectiveness of the preservative portion is in direct relation to the depth of penetration into the wood and the amount that is absorbed. The simpler preservative applications, therefore, should be used only in conjunction with design features restricting wetting and permitting drying. When better treatments are not available, a short-period soak will give worthwhile protection even to porches and steps where the decay hazard is fairly high. Longtime protection should not be expected under such conditions, however.

(4) Sheathing paper used under wood siding should be of the breathing type (Underwriters' Class D). This paper turns wind and liquid water but permits ready passage of water vapor. Vapor permeability is necessary because any water getting back of siding can't dry outward because of the paint; it must dry to the interior of the wall. Water accumulations are particularly bad with flat-backed siding such as drop-siding pattern 105; there is some evidence that furring strips to provide an air space between flat-backed siding and the sheathing paper are beneficial. The sheathing itself tends to favor accumulations of moisture in siding. In the wetter, warmer regions, sheathing is best omitted unless the walls are well protected by roof overhang or the siding is treated with a water repellent

Condensation

As has been mentioned, moisture-laden air from wet crawl spaces sometimes rises up into walls and roof space. The more common type of wall and attic condensation, however, is associated with the migration of warm air from the interior of the building outward through the wall and upward through the ceiling. In cold weather this migrating warm air may come in contact with a cold surface, and then the moisture in it will condense. The inner surface of sheathing is a common point of such condensation. Trouble is most severe in buildings with heat insulation. Correction is attained by installing a vapor barrier as near the warm surface of the wall or ceiling as possible. Good attic ventilation also helps.

Summary

Decay of wood in buildings can be controlled by using dry sound lumber and designing the structure so as to reduce the wetting by soil water, rain condensation, etc. Because some wetting is usually unavoidable, design also should allow for rapid drying following wetting. When moisture control is doubtful or not feasible, decay can be prevented by using a naturally decay-resistant wood or one treated with a preservative, particularly a water-repellent preservative.

The recommended decay-prevention measures may seem formidable but it should be remembered that all measures are not necessary in all buildings. Many control features do not involve extra material and labor but merely entail the proper use of what would be included anyway. Everyone know

of poorly constructed buildings that have somehow escaped major trouble. Such cases are mostly fortunate accidents and cannot be predicted.

The safest procedure is to see that decay-inviting features are not present. Protection can be attained cheaply during construction; it can be costly later. When people realize, this, they tend not to rely on minimum protective measures but to include additional features, such as the greater use of treated wood, for further insurance against future worries.

Discussion

George Stern (Virginia Polytechnic Institute): How long after a concrete slab is poured over a moisture barrier, such as a plastic film, can framing of the structure be started? A considerable amount of moisture is freed from the concrete and can be absorbed by any dry mudsills, sleepers, subflooring, and plates. Would such moisture absorption result in twisting, warping, and decay of the lumber under adverse conditions?

Mr. Verrall: The rate of drying of a slab depends on a number of factors. I cannot give an average safe drying time. Because plates and framing are usually laid on felt or metal flashing, they do not seriously wet from drying slabs. Most trouble arises from imperfect waterproofing permitting continuous water movement up from the soil.

Mr. Stern: Can treated wood be used here immediately?

Mr. Verrall: Yes, treated framing but the slab must be dry before floors are laid.

Monie Hudson (Consulting Chemist): I agree with Mr. Verrall that we can eliminate most of our troubles from wood destroying insects and fungi by proper design. In fact, about 30 years ago most houses in the south were so designed and little trouble was experienced. The houses were not underpenned. However no one who has had to get up on a cold floor in winter in those houses would be willing to return to this "proper design". If we are going to continue to build houses that are comfortable to us, and, incidentally, comfortable to insects and fungi, the most reasonable thing to do is to build them out of materials that these pests can't eat. Wood preserved by pressure processes is such a material.

Mr. Verrall: I do not agree. With proper design we do have dry comfortable houses. Even with pressure-treated substructures we can have wet moldy houses unless moisture problems are corrected by proper design. This automatically removes most decay hazard. Treated wood is good insurance but not essential for decay protection in well-constructed, comfortable houses.

John Reno (Pacific Lumber Co.): I believe wood sheathing and sheathing paper would not allow the wall to suffer from water. In the south would blown rain enter through a brick veneer and collect on the sill or on a termite shield?

Mr. Verrall: Driven rain could enter brick veneer but I believe more water trouble would be caused by condensation moisture. Condensation on cold brick causes moisture to move across metal tie strips and run down the sheathing paper to wet the sill.

John Reno: From your experience then, not enough wind-blown rain would be evident to cause water trouble.

Mr. Verrall: Correct except in unusual cases.

An Analysis of the Employment Letter[1]

C. F. VAN EPPS

Manager, Materials Engineering Dept., Stromberg–Carlson Co., Division of General Dynamics Corporation, Rochester, N. Y.

Summarizes principal items which should be considered in writing letters of application for employment. Directed particularly at college seniors, the analysis emphasizes requirements based on the author's experience with prospective technical employees. Factors discussed include application format, photos, personal details, scholastic and experience records, references, and timing.

THE EMPLOYMENT LETTER forms the first contact of the student with the prospective employer. The significance of this first contact is of primary importance to the technical employee. It is his first "professional" act and is the first reflection of his professional training.

Much of our comment is elementary, but that is the first principle of the letter—it is directed to people whose days are full and who cannot enjoy a narrative version of each student's particular success story. From the employer's viewpoint there are many things about a letter that paint a mental picture of the applicant physically and characteristically.

Ideally, the employer prefers a neat, efficient, and docile-type employee. This may vary with the particular job available. For example, a hard-hitting sales manager or purchasing agent may find the word "docile" inadequate and substitute the adjectives "eager" or "aggressive". But, in general, the employees must be able, physically and mentally, to do the job; he must be eager for the type of work; and he must be able to live and work in peace with his fellow employees. The first letter can give much information on the student in relation to these qualities.

Before proceeding to an analysis, however, it should be pointed out that the items emphasized are the result of our personal experience in contacts with prospective technical employees. The requirements of other companies may vary quite decisively and their analyses may differ somewhat from the pattern which follows.

For FPRS Student Members

This paper is published as a service to FPRS student members who expect to graduate in June. Although not a technical paper, the concensus of reviewers is that it presents a good concise message for the man about to seek his first job.

Application Format

Organization is the general purpose for which the engineer or technician is trained and there is no better place to display it than in the employment letter. Since it is a business letter, it should be on business stationery, preferably a good grade of white paper,

[1]Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

The Author: C. F. Van Epps, graduate of Clarkson College of Technology, is a well-known materials authority with experience in adhesives and plywood fields. He holds several patents and has written numerous technical papers. Mr. Van Epps is former member of FPRS National Executive Board, is a member of ACS, SPE, ASTM, and AES.

8–½ x 11 inches, and folded properly for a business-size envelope.

Visualize the employment letter as a technical report. It should present your case clearly and concisely—in your absence. To do this it must contain sections describing you physically and characteristically with a full description of academic training and experience. Avoid the use of any bizarre device intended as an "attention-getter". It may cause the personnel men to remember your letter—with disastrous results.

Most employment letters are divided into two sections, one in the applicant's hand writing, with conversational style outlining why the applicant is interested in this particular company; the other typed and in tabular form, giving statistical data on the applicant. The importance of handwriting must not be overlooked. The anticipation of reading reports and memos written in a gnarled style leaves most employers cold. And neatness in presentation is a certain indication of neatness in the many facets of technical work. Clarity and continuity together with the simple rudiments of spelling and sentence structure are essential.

Bear in mind that business of today is past the era of "beg to inform you" style. It is direct and forceful, yet it is correct and never-failing in courtesy. Attention to detail, in the aspects listed above, is the first thing expected of every technical man.

Photos

This is an era of visual aids. No amount of written description can be as effective as a well-chosen picture. And the investment in professionally-made photos may be the selling point of your letter. Each employer is keenly interested in the appearance of his employees; the success of his business may depend upon the impression made by these men.

Photos should be a simple head and shoulders in a business suit. Incidentally, the employer generally is not attracted by the applicant's physical beauty, but rather by the sincerity and straightforwardness reflected in a simple photo. The photo is the introduction, so to speak, to the verbal description which follows.

Personal Details

A full description is desirable of height, weight, physical impairments, marital status, number of dependents, alcohol, tobacco, and drug habits, work preferences and other pertinent facts. No detail can be considered immaterial. Full and frank description will avoid later misunderstanding.

Each of the above items is significant, some in respect to one type work, some to another. For example, if selection is being considered for distant assignment, number of dependents is important. Physical impairments may be no hindrance in some situations, definitely disadvantageous in others. Citizenship may be required for classified work or access to classified areas.

Draft or military status should be thoroughly explained. It is recognized that most applicants have some obligation to military training and provisions are made to cooperate in these programs.

Scholastic Record

The basic purpose of technical education is to provide a source of specialized knowledge and a stimulus for acquiring it. How well the student reacted to the presentation is generally reflected in his course record. Much has been said about the first quarter of the class—some highly complimentary, some almost in suspicion. And much more has been said about the second and third quarters—the "average" men of the group. This argument is only decided when the right men are put in the right place in industry.

It is fair to state that, all other factors being equal, a man with high scholastic record will be chosen over those with lesser records. In fact it was general policy until recently for many major companies to interview only the top quarter of the classes. The current technical shortage has changed this approach.

The scholastic record should include secondary school and a four-year breakdown of the college course record. A pattern of substantial improvement from failure to average success in four years may be more important in appraising an individual than a constant, but mediocre, record of passing grades. When you state your record, be sure it is in terms which are universally understood, not cryptic local grading marks.

Experience

In many cases it will be impossible to state experience bearing directly on the type of work under consideration. The facts are important nevertheless. It is unusual today to receive applications detailing no experience, although what experience is cited may vary widely in scope. The student's general performance pattern may be filled in by details of this section.

Describe in detail the jobs you have held. It is possible that some aspect of the job under consideration for you is directly related to the work you have done. This may only become apparent with a complete description of your work experience.

References

References should be positive and constructive. It is well to check carefully all names given as references and to secure permission before their use. Employers are hesitant in accepting glowing commendations without specific points of consideration.

For example, a former instructor may be expected to comment honestly on the attitude, application and progress of the student. A cleric may testify as to the integrity or social awareness of an individual. An employer might review the aptitude, diligence, and earnestness of the student. These are specifics and are useful in evaluating the propect.

Perhaps the most serious difficulty in interpreting the references given is the lack of integrity displayed by many who try to help the applicant unjustifiably. In some cases written references are requested by the applicant, and in these cases particularly it is difficult in many instances to be frank and honest. In most cases the employer will call the reference by telephone and conduct a brief but reliable inquiry into the points in question. This has proven more effective than any written reference.

In all cases select persons who can give a good cross section of your personal habits and academic training. It is elementary that these people should know you well enough to respond intelligently. The head of a department may be better qualified to comment on your over-all scholarship than an instructor in whose course you found a particular interest.

Timing

The timing of the employment letter is important. If it is too early it may well be forgotten by the time of the student's availability. If too late, it may come at a time when the employer's requirements have already been filled.

The right time, in our opinion, is shortly after the first of the year, for anticipated June graduation. This is roughly the time when budgets for the second half year are in a planning stage. It is also early enough to allow some personal contact or interview time before decision by the employer. If no action is forthcoming within a reasonable time, a second "quiet reminder" type letter may be effective.

Bear in mind that many companies to which you will write have no formal personnel department. This means the executive officer will have to find time to read, consider, and answer your letter. Personnel officers will normally have to consider employment requisitions before them at the time of your application. If none, they may solicit the various departments—if

your application is attractive enough to warrant special consideration. Allow sufficient time for satisfactory handling of your letter.

Other Factors

Your preference for a specific geographical area may be well-founded in fact, and the type of work you prefer may be crystal clear. But keep in mind that as your professional career develops these strong tendencies may give way to more attractive areas of employment. In seeking a start for your career, have a definite plan, but allow some reasonable degree of flexibility. The offer that appeared to be a difficult assignment initially might ultimately lead to a rewarding position.

To review briefly, the employment letter is your personal messenger to a busy executive. It should be clear and distinct. It should provide an actual and a verbal picture. And there should be something about it which will appeal to his sense of values. As he looks for quality in his product, he will look for quality in an employee who may be with him a lifetime.

This letter is the first step toward a contract, a contract not lightly made —nor broken. It is probably the most important job you will do in your last year in school. It summarizes your accomplishments to date and requests an employer's attention with a view toward marketing your services. It is worthy of the best possible effort.

The Economics of Waste Wood Utilization[1]

W. B. LINDBERG

Superintendent of Wood Procurement, Fibreboard Products, Inc., Antioch, Calif.

Describes how waste wood usage at pulp mill has increased from 30 to 75 per cent of total raw material needs in six years. Equipment requirements and costs for various types of waste wood suppliers are discussed. Transportation of raw material from supplier to pulp mill is a principal factor limiting more complete utilization.

DURING THE SIX YEARS of operation of our San Joaquin Division pulp mill, there have been many changes in both the raw material supply and plant operation. One of the most satisfying of these has been the great increase in the usage of sawmill and veneer plant waste.

When this mill began operating, we depended heavily on logs for our raw material supply, and used only small quantities of box factory and planing mill waste, and chips from sawmill slabs.

With the development of new and better chippers and debarkers and increased activity in California lumbering, it became apparent that sawmill and veneer plant waste could be processed economically to replace logs. This not only allowed for more complete log utilization, but also gave lumbermen a profitable market for their waste. In these few years, our lumber mill waste wood usage has increased from about 30 per cent to 75 per cent of our total raw material requirements.

Suppliers Classified

Each individual mill which supplies us with waste wood differs in some respect from the next, but can be classified into one of four general types: (1) planing mills or box factories, (2) veneer plants, (3) sawmills with annual productions under 25 million board feet, and (4) sawmills exceeding 25 million board feet in annual production. Each of these types present different problems in transforming the contents of burner conveyors into usable raw material for pulp mills.

Planing mill and box factory waste, which we call box ends, is shipped as developed at the source without processing. Consequently, the supplier's only problem is to transport it from waste conveyor to rail car. This is usually accomplished by adding a connecting conveyor, but in some cases the material is accumulated in tote boxes and carried to the rail car with a fork lift truck.

Since we process this material with a hammer hog, we specify in our orders for such waste that the wood be dry so that it will break up rather than shred, and specify dimensions adaptable to our handling facilities. Because this hogged material is not sufficiently uniform in size to be used unless blended with uniform chips, our purchases of box ends are limited.

Chip Requirements

The balance of our waste wood raw material is produced at the source from sawmill and veneer plant waste, and is shipped to us in the form of wood chips. Precision chippers are used to produce a uniform sized chip acceptable to the chemical cook used at the pulp mill. If the chips are oversize, the pulping chemicals do not penetrate the wood enough to separate the cellulose fibres from the lignin; if they are undersize, the result is a yield loss from overcooking of the fibres.

A chipper with sharp, properly set knives produces few unacceptable chips, and these are screened out at the pulp mill and circulated through a rechipper. Since even small amounts of bark or other foreign material in such wood chips has a marked effect on the quality of the finished product, we can only accept clean bark-free chips.

The second type of mill, the veneer plant, lends itself to the simplest and least expensive chipper installation. Here logs are barked before they are peeled and almost all of the waste is suitable for pulp chips. A short conveyor is commonly placed at the end of the sorting table to feed the chipper and the chips are conveyed pneumatically or mechanically to rail cars. Depending upon the location of the rail spur, such an installation costs from $25–50,000. As a rule of thumb, 3/10 of a standard 200-cubic-foot unit are produced in such mills for each 1,000 board feet of logs cut. The power required to operate such chipping equipment ranges from 100 to 150 horsepower, and one man per shift can handle the operation with the aid of a car winch.

We have classified sawmills into two size groups with the dividing line at an annual production of 25 million board feet. Usually a mill cutting less than this amount cannot produce enough chips to justify the high cost of a whole log debarker, especially if a pine mill is involved. Pine mills often have overriding fuel requirements and closer cutting practices that

[1] Presented at meeting of FPRS Northern California Section, Oct. 28, 1955, in Antioch, Calif.

The Author: W. B. Lindberg attended Stanford University and worked for three years in the logging industry in Washington. He served for five years in the Fibreboard Products pulpwood handling and processing plant before promotion to his present position in 1954.

decrease their chip production potential.

Chipping Costs

In these smaller mills, chipping equipment only is considered and the machinery and installation costs are comparable with the $25–50,000 investment encountered in a veneer plant. However, the existence of bark on much of the waste decreases chip production 50 to 70 per cent so that production generally ranges from 1/10 to 2/10 of a unit per 1,000 board feet of logs cut. The spread in the waste factor can be explained by pointing out that a stud mill producing in conjunction with a veneer plant usually uses lower grade logs than a sawmill operating independently and consequently will develop more waste.

Lumber market fluctuations and the relative location of a mill to its market will also affect chip factors. If we assume that an annual chip production of 3,000 units is necessary to justify the expense of a chipping plant and maximum chip to log cut ratio of 2/10 of a unit per 1,000, it follows that a sawmill must cut a minimum of 15 million board feet a year in order to justify the addition of waste processing machinery. In one case, however, a mill cutting only about 10 million board feet a year is successfully supplementing its normal waste with cull lumber from small neighboring mills to increase its chip output.

The chipper is usually placed beside the refuse conveyor and is gravity fed by the operator who also operates a car spotting winch. If the refuse conveyor is located close enough to the rail spur, a top discharge type chipper with fins on the rotating disc can be used to blow chips directly to the rail car with no need for additional conveyors. Advances in chipper design have enlarged the feed spout opening so that a smaller machine can now be used. For example, a few years ago a 72-inch chipper had a spout opening of 14 by 14 inches and required a 250-horsepower motor. Today a smaller 66-inch chipper has a 10- by 20-inch feed spout and requires only 150 horsepower. The emphasis today is on wide-slab capacity.

Debarking Costs

Mills producing over 25 million board feet a year and having at least a ten-year timber supply can usually justify the addition of a whole log debarker. Mechanical debarkers have an advantage of lower initial cost and require only about 150 horsepower, but are limited to a maximum log diameter of 60 inches. Hydraulic debarkers cost more, require in excess of 1,000 horsepower, and present a water supply and effluent problem. They will, however, process larger logs. The addition of a debarker will about triple the bark-free chip potential of a sawmill so that a pine mill can be expected to produce about 3/10 of a unit per 1,000 board feet log cut and a Douglas-fir mill about 4/10 of a unit per 1,000.

Sixty-inch mechanical debarker installations cost from about $150–200,000. Many of these machines are being placed in existing log hauls and can be quickly moved vertically or horizontally to allow for passage of oversized logs. In some mills pond-to-pond or separate log-haul installations are more desirable.

Hydraulic debarkers cost up to $750-000 and because of their high cost and water problems are usually practicable in only the largest sawmills.

While considering these first costs, it is interesting to note that reports from mills operating debarkers indicate increases in lumber production of from 5 to 10 per cent, higher grade recovery, and savings in saw life and mill cleanup. It is generally conceded that these advantages alone pay for debarker operating costs. In addition, chip-producing sawmills undoubtedly realize savings from lower burner maintenance and replacement costs.

Transportation Factor

This pulp mill is located at Antioch on the San Joaquin River because of our requirement of about 15 million gallons of water a day. The great distance that our raw material must be moved limits us almost entirely to suppliers with rail facilities who can produce enough waste to fill rail cars without developing demurrage charges.

One of the biggest problems is transporting waste wood from the source to the pulp mill. Some suppliers are as far as 300 miles away and over-all freight costs exceed the cost of the product. Although special high-sided, bottom dump gondolas and open top box cars have been built by the railroad, the demand continually exceeds the supply. We have about 50 waste wood suppliers, some of them producing both box ends and chips. Adjustments in sawmill production and fuel inventories mean constant changes in traffic coordination in order that rail cars can be fully utilized.

There have been many fine advancements in machines and technology in recent years, and we look forward to the day when new developments will make waste recovery practical in both small sawmills and logging operations, leaving the woods free of obstructions to future timber crops.

Around the World in Forest Products Research and Development

Australia Laboratory Studies Wood Collapse

Research aimed at ultimately establishing whether a method exists to prevent collapse from occurring altogether during drying is being carried out by the Division of Forest Products, C. S. I. R. O., Australia. In the absence of a method for preventing collapse, a prediction of collapse intensity in individual logs prior to drying is being sought. One method which has recently been sucessfully tested involves drying segments of logs, thus obtaining an indication of expected collapse behavior from pith to bark.

Results are constantly being applied to practical timber seasoning and have been instrumental in the development of the predrier and of low temperature veneer drying schedules with low wet-bulb temperature, designed to keep collapse to a minimum. Better understanding of the physical and chemical basis of collapse behavior will undoubtedly result in progressive improvement of methods for the treatment of collapse-susceptible timber.

Collapse (an abnormal type of shrinkage due to caving-in of cell cavities during drying above fiber saturation point) was first recognized by Harry D. Tiemann, U. S. Forest Products Lab, in 1913. In 1915 Tiemann proposed the theory that collapse is primarily induced by liquid-tension forces acting in "free" water in completely filled fibers. This theory is being studied by experiments designed to vary the surface tension of the "free" water by using wetting agents or replacing water with other liquids. In another series of tests, attempts are being made to vary the number of so-called "nuclei" or minute gas bubbles in the "free" water. One method consists of soaking specimens in air-free water, and then subjecting them to high pressures before drying.

High temperatures applied to moist wood prior to drying have been found to cause degradation and increase collapse during subsequent seasoning. The exposure time is important: a high temperature for a short time may not cause as much damage as a lower one for a longer time. Experiments are proceeding to investigate the reasons for this behavior. Preliminary results show that by chemically extracting certain cell wall constituents, normal wood can be made to approach tension wood in its composition and in its gross shrinkage during drying. Whether this change in behavior is a direct consequence of the extraction, or of other effects such as breaking of chemical bonds or blocking of minute capillaries, remains to be seen.

—C. S. I. R. O. Forest Products Newsletter

Other Developments Around the World

India

• Research on the production of high alpha cellulose pulp from Eucalyptus globulus has shown that it is possible to use the species for manufacture of viscose rayon pulp. Research is being carried out under the Ministry of Commerce and Industry at the Forest Research Institute, Dehra Dun.

The pulp was prepared on a laboratory scale by the prehydrolysis sulphate process with 42 per cent yield, and was tested by a rayon pulp manufacturing firm in Germany. This is the first time that viscose rayon pulp has been prepared in India, even on the laboratory scale, from wood grown in the country. Other species are being tested.

United Kingdom

• An Institute of Wood Science has been established for the purpose of "advancing scientific, technical, practical and general knowledge of persons interested in the study of wood and allied subjects." Made up of wood technologists, botanists, chemists, consultants, and representatives of timber trade, technical colleges, and technical associations, the Institute plans to publish a Journal of Wood Science. The Journal will contain original articles dealing with all aspects of wood science, with considerable space devoted to reviews and summaries of current research, and a news bulletin.

—Unasylva, Vol. 10, No. 4.

Yugoslavia

• Two-thirds of the industrial capacity of Yugoslavia was demolished or destroyed during World War II. Much of this has been rebuilt in the post-war period, so that if 1939 production is considered at 100, total production in 1955 had risen to an index of 242. The wood industry index (excluding wood pulp) is far below this overall general index, amounting to 147, or 160 when taken with cellulose production.

Production has developed as follows for individual products and groups of products. The production of sawn timber increased rapidly in 1948–50, but has decreased since that time, and in 1955 amounted to 97 per cent of the 1939 production and 58 per cent of the 1948–50 period. Production (in 1,000 cubic meters) was 1542 in 1939, 2319 in 48–50, and 1258 in 1955. Production of veneers increased from 5,100 cu.m. to 12,600 cu.m. Production of oak veneers decreased due to exhaustion of forests of Slavonia, while production of all other kinds increased.

Plywood production increased from 13,300 cu.m. in 1939 to 23,300 in 1954. Fiberboard production was started after World War II, and the average yearly production was 10,592 tons in 1954. Expansion up to 90,000 tons is foreseen. Home furniture production is increasing steadily from 21,000 sets in 1946 to 143,000 in 1955. Cellulose and paper production has increased from 28,300 tons in 1939 to 194,000 tons in 1955.

—Yugoslav Timber Industry

Scanning World-Wide Forest Products Publications

India

Treatment of Green Canes by the Diffusion Process. A. Purushotham and M. C. Tewari. Journal of the Timber Dryers' & Preservers' Association of India.

Diffusion experiments using large quantities of canes were carried out using water solutions of boric acid, zinc chloride, ascu and Basilit UA special. Experiments were also carried out to study the diffusion of water soluble dyes in canes, as colored canes are of considerable importance in manufacture of artistic articles.

Details of the experiments are given and conclusions drawn which show that green canes can be treated satisfactorily by the diffusion process using 2 per cent solutions of boric acid in one to two weeks, zinc chloride in three weeks, and ascu and basilit UA special in four weeks. Dyeing of green canes can also be carried out using 0.1 per cent crocein scarlet in about four to six weeks.

Abstracts From Current World Literature

Barkers and Barking

American Pulpwood Association. New mechanical debarker uses cambium shear principle. Paper Trade J. 140, no. 12: 38, 40 (March 19, 1956).

A summary of existing data on the Cambio debarker is presented; three debarkers are now in this country and might be considered pilot models. [Bul. Pap. Chem. V. 26, No. 8]

Grondal, Bror L. New process barks alder. Pulp & Paper 30, no. 3: 125–6 (March, 1956).

The use of alder(*Alnus rubra* Bong.) as a pulpwood in the Pacific Northwest is increasing; in most instances it is reduced to pulp by the kraft process. In chipping no attempt is made to remove the relatively thin bark which is rather completely cooked away yielding very little pulp of acceptable quality. When cooked by the sulfite process, most bark must be removed, as it will not cook away as in the kraft process. A flotation process was developed for this purpose which is based on the fact that fresh green chips from winter-cut alder will float, whereas bark particles sink in the water. A tank for this purpose is proposed in which the chips are first completely immersed in water with the aid of a rotating drum or a submerged belt. The chips come to the surface, and the bark drops to the bottom; from here it is periodically removed. The tank should be deep enough to permit the bark to sink in relatively undisturbed water. The flotation apparatus may even be worth while for chips from logs which have been debarked by mechanical means, because the percentage of liquor-consuming fines in such chips is surprisingly high. [Bul. Pap. Chem. V. 26, No. 8]

Log Grading

Flick, F. J. Grading logs and trees for quality: a bibliography compiled for the Log Grade Committee, Forest Service. U. S. Forest Service, Washington, D.C. 1955. pp. 27.

Gives 245 references, all dealing with N. America, and arranged by regions. [For. Abs. V. 17, No. 1]

Finishing

C. B. Stupples. Cellon Ltd. Developments and trends in the finishing of furniture. *Industrial Finishing*, Vol. 9 No. 92, February 1956, pp. 371–2.

Roller coating is already widely used on the Continent and in Scandinavia, but may find restricted use here, due to British design. Unit and contemporary furniture, which have simple lines, offer scope for exploring this method, but in addition the straight panels used in the back and sides of wardrobes, sideboards etc., can be coated in this way.

The scraping process has recently been re-introduced from Denmark. The main piece of equipment required is a machine which can precision hone the scraper blade to the required squared edge. Before staining the timber is sponged with water in the cabinet shop, then scraped to remove raised grain. Water-base colors are then used for staining and the grain does not rise again. Coloring is carried out by concentrated water base staining applied by spray before any lacquer coats. Three sprayed coats of hot lacquer are applied with a minimum interval of 1½–2 hr. The work is then allowed to stand for 48 hr. before scraping and burnishing. This method is claimed to eliminate sinking.

A new approach to the problem of sinking is the process of pre-filling. The pre-filling compound is thinned to a creamy consistency and applied by rag. It dries hard in about 30 min. and is then sanded in the usual way.

Slatted chairs, deck chairs, inexpensive book cases and similar articles can be finished satisfactorily by dipping. The usual arrangement is a two-coat process consisting of a dipping sealer tinted to the required color, lightly scuffed and followed by a dipped or sprayed clear lacquer coating.

The use of cold-cure catalysed resistant wood finishes is gradually increasing. Recent developments in cold-cure lacquers have led to reduced drying times, which are now approaching cellulose schedules. For hard wear and retention of appearance the cold-cure resistant finish has the advantage over cellulose. [F. D. C. Tech. Bul. V. 5, No. 29]

Wood Chemistry

Stamm, Alfred J. Thermal degradation of wood and cellulose. *Ind. Eng. Chem.* 48, no. 3: 413–17 (March, 1956).

Activation energies and relative reaction rates have been calculated for the thermal degradation of wood, wood components, cotton, rayon, and rag and sulfite papers, from data on both weight loss and strength loss under dry heating and steaming conditions. Weight and strength loss give similar activation conditions. Dry heating gives higher activation energies than steaming. Isolated hemicelluloses degrade about four times as fast as wood and isolated α-cellulose. Isolated lignin degrades at only half the rate of the wood. Estimates are made of the degradation of wood under kiln drying conditions and of the weight and strength losses of dry wood and the strength loss of dry paper on prolonged storage at room temperature. [Bul. Pap. Chem. V. 26, No. 8]

Chemical Composition of Wood. Canadian Pulp and Paper Association. Technical Section. Engineering Data Sheet Committee. *Pulp Paper Mag. Can.* 57, no. 1: 84 (Jan., 1956).

Average values of density and chemical composition (holocellulose, Cross and Bevan cellulose, lignin, total pentosans, and solubility in ether) for a number of common hardwoods and softwoods are presented in tabular form. [Bul. Pap. Chem. V. 26, No. 7]

Veneer and Plywood

K. V. Cokley, B. L. Adkins and E. J. Rees. The determination of moisture content in rotary cut veneers by hygrometric methods. *The Australian Timber Journal*, Vol. 21 No. 1, August 1955, pp. 641, 643–4, 647–8.

The effectiveness of the glue-line in plywood largely depends on the moisture content of the veneers used. The oven-drying test for moisture content is too lengthy for purposes of routine control, and electrical moisture meters are unsuitable for use on veneers treated with preservative or anti-insect chemicals.

Extensive tests were carried out using the Lambrecht contact hair hygrometer on "hoop pine", yellow carabeen and brown tulip oak to find out whether moisture content could be determined by measuring surface relative humidity. The experiment was successful, the standard error being 0.9%, and it is possible that the method could be used for other species with equal success. For veneers thicker than 1/16 in. there are no positive results as yet. The method is not suitable for wood treated with deliquescent (water-absorbing) chemicals. [F. D. C. Tech. Bul. V. 5, No. 29]

Wood Properties

The intermicellar system of cellulose fibres. *Rep. Commonw. sci. industr. Res. Organ. Aust. 1953/54* 1954 (89).

The magnitude of capillary spaces has been investigated in fibres from spruce, various eucalypts, and flax, using the method of gold deposition. Examination of gold-impregnated material by means of the electron microscope has resulted in a visual demonstration of the intermicellar system. [For. Abs. V. 17, No. 1]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

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TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing indusrty. Subscription price is $5 per year.

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Review of FPRS Section Meeting Papers

Design and Operation of New Sawmill

Harry E. Bovay, Jr., Consulting Engineer, Houston, Texas. Mid-South Section Meeting, Nov. 7–8, 1955, in Memphis, Tenn.

Incorporating the best features of the nation's most modern sawmills, Kirby Lumber Corp.'s new plant at Silsbee, Texas, has an estimated annual capacity of 87 million feet. Logs come into the mill from Kirby's 550,000 acre tree farm holdings which are selectively harvested for perpetual yield. Eighty per cent of each log is converted into saleable material and the balance is fed as fuel to boilers for steam generation, completing the cycle of 100 per cent utilization.

The new mill is doing the work of five smaller mills originally operated by Kirby at the inception of the planning. It is producing a higher quality product and by-products not produced previously, and is doing this with less manpower.

The production capacity of the plant was designed for 300,000 feet board measure per day, or 75 million feet per year. Provision is made for an additional 12 million feet per year of green lumber purchased from others. The complete output of the plant is Southern yellow pine.

The sawmill and green end operate two shifts per day; the kilns and power plant operate around the clock; and the milling and shipping operations work one shift per day. Most of the lumber goes into 1- and 2-inch boards, dimension stock, and a complete line of kiln-dried, finished pine products, including pattern and end-o-match stock.

The mill can produce up to 30,000 feet board measure per day of heavy timbers, up to 32 feet long, plus lighter timbers and special framing stock. This heavier stock can be handled, stored, and loaded directly at the sawmill, by means of an outdoor timber crane, or it can be sorted and stacked for kiln drying at the timber sorter.

An important by-product is the conversion of all sawmill waste into chips for pulp. The chip plant was designed for 35,000 cords of chips per year but is producing far above this figure. All waste from the rough mill and planing mills, together with the bark from the logs, goes to the fuel vault and is fired in boilers at the power plant. This generates the total requirement of steam and electric power for the mill, with provision for future additions. Steam is used to dry lumber in the dry kilns. The entire plant is electrified with individual drives.

Conservation of Material in Furniture Manufacture

Wayne Hutchins, American Seating Co., Grand Rapids, Mich. Panel Discussion, Economy of Materials in the Furniture Plant, North-Central Regional Meeting, Nov. 15–17, 1955, in Chicago, Ill.

Practices which we use to help conserve materials in manufacture of wood products include: salvaging warped plywood panels, roller coating of finish material, and an incentive wage plan in the rough mill.

The Quality Control Department has specified warpage tolerances for specific products. The allowable twist or cup depends on the location of the part and how it is fastened in the finished product.

The inspection department checks plywood for warpage in blank form prior to machining. Inspection is facilitated by the use of jigs made specifically to measure twist or cup. In measuring twist, for instance, three corners of a plywood panel are laid flat on a steel plate. The distance the fourth corner is out of plane is indicated by a movable pointer on a go-no-go basis.

There is enough variation in the method of fastening school desk tops to allow diverting warped tops to specific products. In addition, we practice cutting down to a smaller size to reduce overall warpage or cut out defects.

Roller coating of finishing material works well in certain products, although we have not been able to apply top coats of lacquer to writing surfaces because of insufficient flow properties of the finishing material. We feel that roller coating is about half as expensive as spray coating and most of the savings is in material.

The cutting room group incentive plan was instituted in 1929 with the aid of a consulting firm following a series of time studies on varied products involving different kinds and grades of lumber.

It is a group incentive plan for cutters, rippers, and off-bearers who cut and rip wood products to rough dimensions. The basis of the plan is the board feet of lumber cut and ripped per man hour and the percentage of lumber waste. Charts determine the percentage of incentive earned accordingly.

The emphasis is on minimum waste and a higher incentive rate may be earned by keeping waste percentage low even though man hours may increase. However, this plan has conserved both lumber and man hours since it was started.

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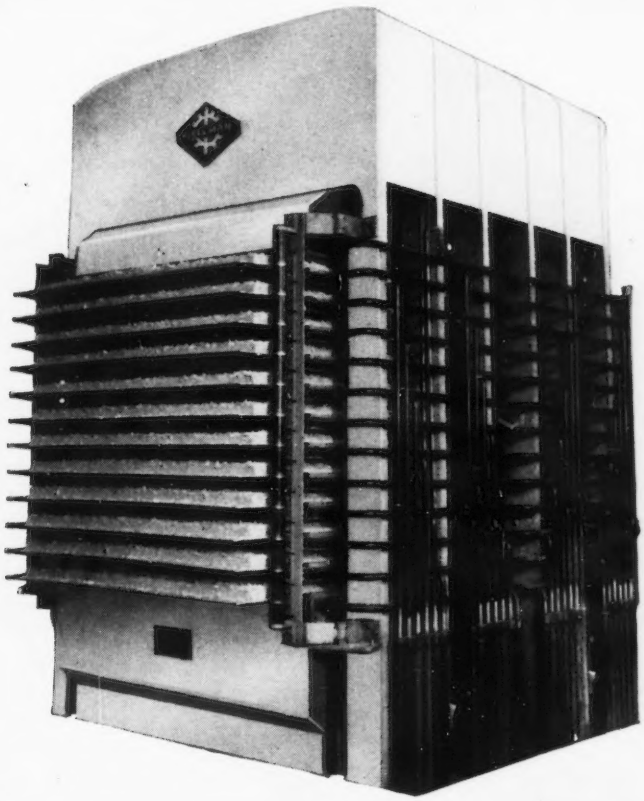
from Particles to Profits

FJELLMAN AMERICAN HYDRAULIC HOT PRESSES



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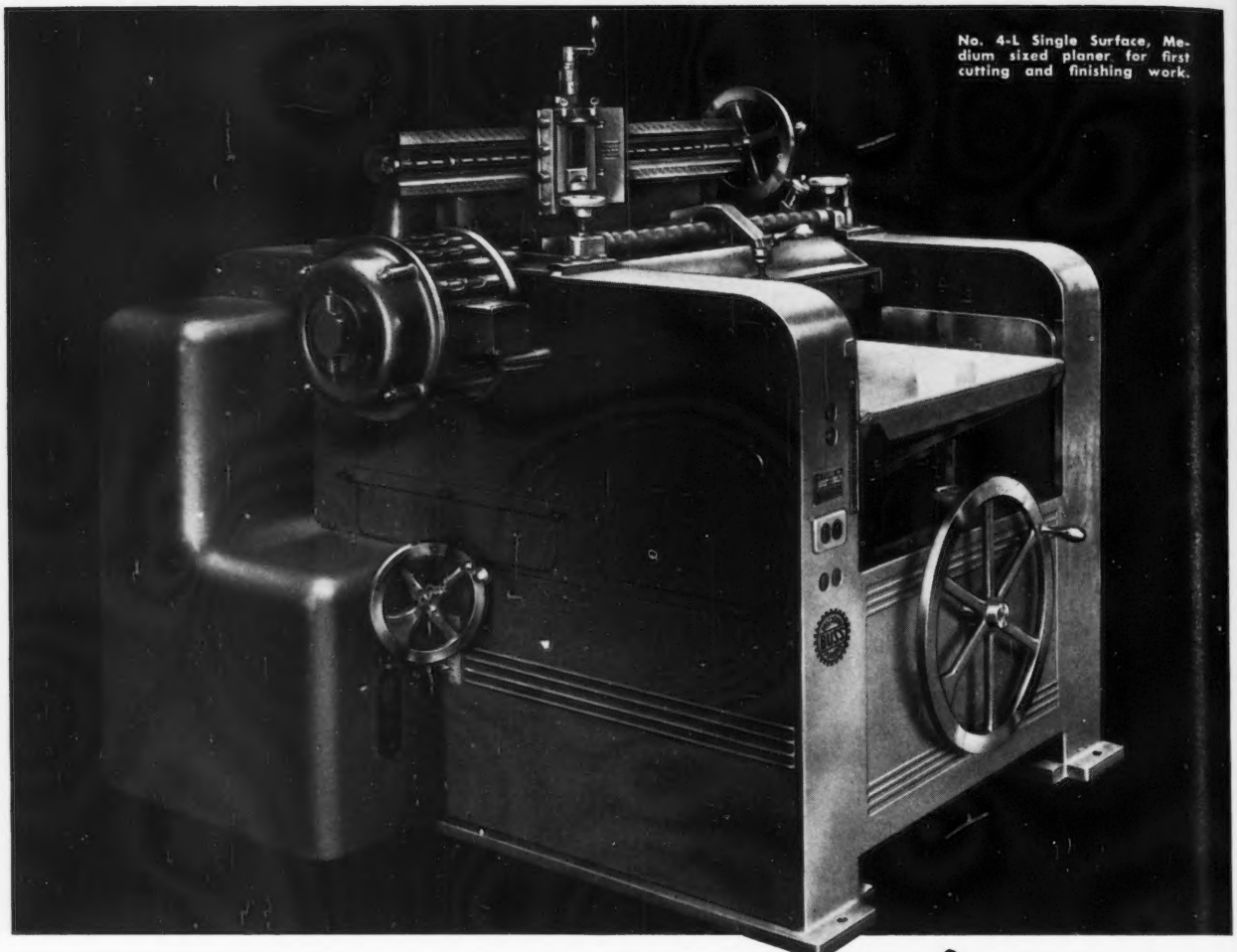

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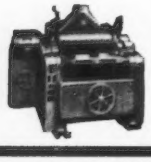

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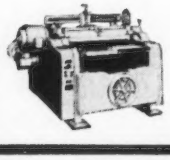

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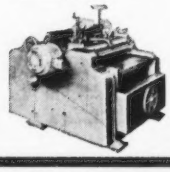

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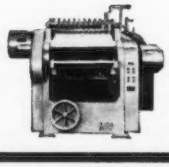

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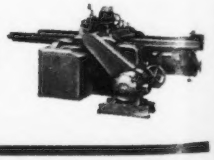

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